TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799
VOLUME XIV 1908-10

Publications of Yale University

A2330

PUBLISHED UNDER THE AUSPICES OF
YALE UNIVERSITY
NEW HAVEN, CONNECTICUT
1910

THE R. WAGNER SOHN PRESS

1752(4)

OFFICERS FOR 1908-10.

President.

HON. SIMEON E. BALDWIN.

Vice-Presidents.

PROF. ALEXANDER W. EVANS, PROF. CLIVE DAY,
PROF. HANNS OERTEL.

Secretary.

DR. GEORGE F. EATON.

Treasurer.

MR. LEE McCLUNG.

Librarian.

PROF. JOHN CHRISTOPHER SCHWAB.

Committee on Publication.

HON. S. E. BALDWIN, Chairman,
PROF. A. S. COOK,
PROF. E. S. DANA,
PROF. E. P. MORRIS,
PROF. A. W. EVANS,
PROF. CLIVE DAY,
PROF. H. OERTEL,
PROF. J. C. SCHWAB.

CONTENTS.

	PAGE
Additions to the Library, April 1, 1908 to April 30, 1910	VII–XXXII
Art. I.—On the Theory of Double Products and Strains in Hyperspace. By Edwin Bidwell Wilson.	1–57
Art. II.—The Morphology of Ruppia Maritima. By Arthur Harmount Graves.	59–170
Art. III.—Supplement to the New England Spiders. By J. H. Emerton.	171–236
Art. IV.—The Poems of Thomas Third Lord Fairfax. By Edward Bliss Reed.	237–290
Art. V.—The English Moral Plays. By Elbert N. S. Thompson.	291–413
Art. VI.—The Accentual Cursus in Byzantine Greek Prose with Especial Reference to Procopius of Cæsarea. By Henry Bronson Dewing.	415–466

ADDITIONS TO THE LIBRARY

OF THE

CONNECTICUT ACADEMY OF ARTS & SCIENCES

By Gift and Exchange from April 1, 1908, to April 30, 1910.

Aix-en-Provence.—*Université.*
Faculté des lettres. Annales III, 3–4. 1909.

Alabama.—*Department of Archives and History.*
Bulletin. I, 2. 1904.
Circulars. 3, 6, 7–8, 10–11.

Altenburg, S.-A. *Naturforschende Gesellschaft des Osterlandes.*
Mitteilungen aus dem Osterlande. I–XII, XIV, XVI, XVII, N. F., II–III, V–IX, XII–XIII. 1837–1908.

American Academy of Arts and Sciences.
Memoirs. N. S., X (II–III); XI (II, 1, III, 2–3, IV, 4–5, VI, 7); XII (I), XIII (II–VI).
Proceedings. XLIII, 15–XLV, 11. 1909–10.

American Antiquarian Society.
Proceedings. N. S., XIX–XX, 1. 1908–09.
Salisbury Memorial: a Tribute from Yucatan. 1906.

American Astronomer.
Bulletin. II, 3. 1909.

American Geographical Society.
Bulletin. XL, 3–XLII, 2. 1908–10.

American Museum of Natural History (New York).
Bulletin. XXVI–XXVII. 1909.
Reports. XL. 1908.
American Museum Journal. VIII–X, 2. 1908–10.

American Philosophical Society.
Proceedings. XLVIII, 191–93. 1909.
Transactions. N. S. XXI (V).

Ames Botanical Laboratory.
Contributions. 4, 6–8, 10. 1906–09.
Ames, O. Orchidaceae, Fasc. I–III, 1905–08.

Amherst College.
Catalogue. 1908–09.

Amiens.—*Société Linnéenne du Nord de la France.*
Bulletin. XVIII (1906–7), 369–80.
Mémoires. XII. 1905–08.

Académie des Sciences.
Mémoires. XXXI–XXXIV. L–LV. 1884–1908.

AMSTERDAM.—*Koninkl. Akademie van Wetenschappen.*
Jaarboek. 1907–08.
Proceedings. Section of sciences. X, 1–XI, 2. 1808–09.
Verhandelingen. Afd. Natuurkunde, Sectie I, Deel IX, 5–7, X, 1; Sectie II, Deel XIII, 4–6, XIV, 1–4, XV, 1.
Verslagen van de gewone vergaderingen van de wis- en natuurkundige afdeeling. Deel XVI, 1–XVII, 2. 1908–09.

AUGSBURG.—*Naturwissenschaftlicher Verein für Schwaben und Neuburg.*
Bericht. XXXVIII. 1908.

Australasian Association for the Advancement of Science.
Report of meeting. XI. 1907.

Australian Museum (Sydney).
Memoir. IV. 1909.
Records. VI, 1–VII, 3. 1908.
Report. LIII–LV. 1907–09.
Special Catalogue. No. I. Vol. II (Nests and eggs of birds by A. J. North.)

BAMBERG.—*Naturforschende Gesellschaft.*
Bericht. XIX, XX. 1907.

BASEL.—*Naturforschende Gesellschaft.*
Verhandlungen. Bd. XIX, 3–XX, 2. 1908–10.

BATAVIA.—*Magnetical and Meteorological Observatory.*
Observations. Vol. XXIX and Append. I to vol. XXX. 1909.
Regenswaarnemingen in Nederlandsch-Indië. Jaarg. XXIX–XXX. 1907–08.
Bemmelen, W. van. Rainfall in Java. 1908.

Baylor University.
Bulletin. XI, 3; XII, 1. 1908–09.

BELGIUM.—*Académie Royale d'Archéologie de Belgique.*
Annales. LXI, 6e sér., T. I—Livr. 2–3. 1909.
Bulletin. 1908, II–V. 1909, I–IV.

BERGEN.—*Museum.*
Aarbog. 1907, 2–3; 1908, 1–3; 1909, 1.
Aarsberetning. 1907–08.
Sars, G. O. Account of Crustacea of Norway. XVII–XXVI. 1907–09.

BERLIN.—*Königl. Museum für Naturkunde.*
Bericht. 1907–08.
Mitteilungen aus der zoologischen Sammlung. III, 4–IV, 2. 1908–09.

Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History, Honolulu, S. I.
Occasional Papers. III, 2; IV, 3; V, 2.
Memoirs. II, 3–4. 1909–10.
Sharp, D., Fauna Hawaiiensis, III, part V. 1909.

BOLOGNA.—*R. Accademia delle Scienze dell'Istituto di Bologna.*
Memorie. Classe di Scienze Morali. Sezione di Scienze Giuridiche Ser. I. Tomo II, 1–2; III, 1. 1907–09. Sezione di Scienze Storico-Filologiche. Ser. I. Tomo II, 2; III, 1. 1907–09.
Rendiconto. N. S. Vol. XI–XII. 1906–08.
Classe di Scienze Morali. Ser. I. Tomo I, 2; II, 1–2. 1907–09.

BOMBAY AND ALIBAG.—*Government Observatories.*
Magnetical, meteorological and seismological observations. 1902–05.

BOMBAY.—*Bombay Branch of the Royal Asiatic Society.*
Journal. No. LXIII. 1908.

BONN.—*Naturhistorischer Verein der preussischen Rheinlande, Westfalens und des Regierungs-Bezirks Osnabrück.*
Sitzungsberichte der niederrheinischen Gesellschaft für Natur- und Heilkunde. 1907, 2–1909, 1.
Verhandlungen. LXV, 1–LXVI, 1. 1908–09.

BORDEAUX.—*Académie Nationale des Sciences, Belles-Lettres et Arts.*
Actes. 3e sér. Année 67–69. 1905–07.

Commission Météorologique de la Gironde.
Observations pluviométriques et thermométriques. Juin, 1906 à Mai, 1907. 1907, Part II.

Société des Sciences Physiques et Naturelles.
Mémoires. IV, 1–2.
Procès-verbaux. Année. 1906–08.

BOSTON.—*Museum of Fine Arts.*
Annual Report. XXXIII–XXXIV. 1908-09.
Bulletin. No. 32–43. 1908–10.

Society of Natural History.
Occasional Papers. VII, 8–11. 1908–09.
Proceedings. XXXIV, 2–8. 1908–10.

BRADFORD.—*Scientific Association.*
Journal. Jan., 1909 to Jan., 1910.

BREMEN.—*Meteorologisches Obvervatorium.*
Deutsches meteorologisches Jahrbuch. Jahrg. XVII–XIX, 1907–08.

Naturwissenschaftlicher Verein.
Abhandlungen. Bd. XIX. 2–3 und Beilage. 1908–09.

BRESLAU.—*Schlesische Gesellschaft für vaterländische Cultur.*
Jahres-Bericht. LXXXV–LXXXVI, 1907–08.

Brighton and Hove Natural History and Philosophical Society.
Annual Report and Abstract of Papers. 1899–1909.

BRISTOL.—*Naturalists' Society.*
Proceedings, 4th Ser. I, 1–3 and index; II, 1–2. 1905–09.

BROOKLYN.—*Museum of the Brooklyn Institute of Arts and Sciences.*
Cold Spring Harbor Monographs. VII. 1909.
Museum News. IV, 5; V, 5. 1909–10.

Brooklyn. Science Bulletin. I, 10–16. 1907–09.
Year Book. 1897/8–1900/1, 1904–05, 1906–07.

Brünn.—*Naturforschender Verein.*
Bericht der meteorologischen Commission. XXV. 1907.
Ergebnisse der phaenologischen Beobachtungen aus Mähren und Schlesien im Jahre 1905.
Verhandlungen. Vol. XLV–XLVI. 1906–07.

Brunswick.—*Verein für Naturwissenschaft.*
Jahresbericht. II–XV.

Bruxelles.—*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique.*
Bulletins. Classe des Sciences. 1907, 9–1909, 8.
Annuaire. LXXIV–LXXV. 1908–09.
Mémoires de la Classe des Sciences. 2e Sér. Tome I. Fasc. V; II. Fasc. I; IV, V, in 8vo; II. Fasc. II–III, in 4o. 1909.
Notices. 1907–09, 5e ed.

Observatoire Royale de Belgique.
Annales Astronomiques. X, XI^2, XII^1. 1907–09.
Annales. Nouv. sér., Annales météorologiques. XX, Fasc. IV, C 1 & 2
Annales (Physique du globe). IV, 1–2. 1909.
Annuaire Astronomique. 1909, 1910.
Annuaire Météorologique. 1908–09.

Société Entomologique de Belgique.
Annales. Tome LI–LII. 1908–09.
Mémoires. XV–XVII. 1908–09.

Société Royale de Botanique.
Bulletin. XLIV, 1–3 & annexe; XLV, 1–3. 1907–08.

Société Royale Belge de Géographie.
Bulletin. XXXII, 1–6; XXXIV. 5. 1908–09.

Société Royale Zoologique et Malacologique.
Annales. XLI–XLIII. 1906–08.

Société Scientifique de Bruxelles.
Annales. XXXII, 2, and 2 supplements; XXXIII. 1–XXXIV. 1. 1907–10.
La Revue des Questions Scientifiques. 3e rér. XIV, 3–XVI, 1. 1908–09.

Bucarest.—*Observatorul Astronomic şi Meteorologic.*
Bulletin lunar. Annul XVII—XVIII. 1908–09.

Société des Sciences.
Bulletin. II, 7–12; III, 5–6; VI; VII; IX; X, 5–6; XVI, 3–XVIII, 1. 1894–1909.

Budapest.—*Academia Scientiarum Hungaricarum.*
Mathematische und naturwissenschaftliche Berichte aus Ungarn. XXI–XXIII. 1903–06.
Rapport sur les travaux. 1899–1908.

Budapest.—*Königl. Ungarische Reichsanstalt für Meteorologie und Erdmagnetismus.*

Bericht. VIII. 1907.
Jahrbücher. XXXVI. 1906.
Bibliothek, Verzeichnis erworbener Bücher. VII. 1908.
Officielle Publikation. VII–VIII. 1909.

Buenos Aires.—*Direccion General de Estadistica.*

Boletin mensual. VII, 69–X, 107. 1906–09.

Deutscher Akademischer Verein.

Veröffentlichungen. 1899–04.

Deutscher Wissenschaftlicher Verein.

Stöpel, K. T. Reise in das Innere der Insel Formosa. 1905.

Museo Nacional.

Anales. Ser. 3. IX–X. 1908–09.

Sociedad Científica Argentina.

Anales. LXIII, 4–LXIII, 6. 1907–09.

Buffalo.—*Society of Natural Sciences.*

Bulletin. IX, 1–3. 1908–09.
Report. 1887, 1895–98.

Burton-on-Trent.—*Natural History and Archæological Society.*

Transactions. V, 2. 1909.

Caen.—*Société Linnéenne de Normandie.*

Bulletin. 5e. sér. X; 6e sér. I. 1906–09.

Calcutta.—*Asiatic Society of Bengal.*

Journal and Proceedings. III, 5–10; IV, 1–11 and extra number 1907–09.
Memoirs. II, 5–11. 1909.

Historical Society.

Annual report. 1909.
Journal V (no. 10). 1910.

California Academy of Sciences.

Proceedings. III, 41–56. 4th Ser.

Cambridge (England).—*Philosophical Society.*

Proceedings. XIV, 5–6; XV, 1–4. 1908–10.
Transactions. XX, 11–16; XXI, 1–11. 1907–09.

Canada.—*Geological Survey.*

Preliminary Report on: Portion of main coast of British Columbia, 1908; Part of Similameen District, 1907; Cowganda mining division, 1909.
Reports on: Portion of Conrad & Whitehorse mining districts, Yukon, 1908; Discovery of gold at Notre-Dame de la Salette, 1908; Descriptive sketch of the geology, 1909.
Summary Report. Department of mines. 1906, 1908.
Annual Report. XVI, 1904; Index, 1885–1906.
Annual Report. Department of Mines, Mines branch. 1906.
Maps. 973, 980, 981, 1026, 1035, 1041, 1044–49, 1050, 1059, 1073.

CANADA. Plans. 622, 642–43, 645–46, 648–50, 666, 701, 709, 721, 740, 765, 768, 773, 832, 843–44, 937, 995, 1012.
Sheets. 11 (2), 39, 40–41, 49, 53–55, 66–71, 73, 100–01.
Meteorological Service, Monthly Weather Review. XXXII, 5–XXXIII, 10. 1908–09.
Six miscellaneous reports. 1906–07.
Minister of the Interior.
Canada's fertile northland, ed. by E. J. Chambers, Ottawa. 1908.
Canadian Institute.
Transactions. VIII, 2–3.
Caradoc and Severn Valley Field Club.
List of members. 1896, 1906, 1910.
Transactions. I, 1, 3, 4; II, 1–V, 1.
Record of bare facts. 1893–1908.
CASSEL.—*Verein für Naturkunde.*
Abhandlungen. XLVIII–LII.
CATANIA.—*Accademia Gioenia di Scienze Naturali.*
Bolletino delle Sedute. Ser. II, 1–10. 1907–09.
Società degli Spettroscopisti Italiani.
Memorie. XXXVI–XXXVIII. 1908–09.
Cellule (La). XXIV, 2–XXV, 2. 1907–09.
CHELTENHAM.—*Natural Science Society.*
Proceedings. New Ser. I, 1–3. 1907–09.
CHEMNITZ.—*Naturwissenschaftliche Gesellschaft.*
Bericht. IX, XI, XVI, 1884–1907.
CHERBOURG.—*Société Nationale des Sciences Naturelles.*
Mémoires. XXXVI. 1909.
CHICAGO.—*Academy of Sciences.*
Bulletin. III, 1–3. 1910.
Special Publications. 2. 1908.
Field Museum of Natural History.
Publications. 127–41. 1910.
CHRISTIANIA.—*Videnskabs Selskabet.*
Forhandlinger. 1907–08.
CHUR.—*Naturforschende Gesellschaft Graubündens.*
Jahresbericht. Neue Folge. LX–LXI. 1907–09.
CINCINNATI.—*Lloyd Mycological Museum.*
Bulletin. 3, 6, 9, 11. 1907–09.
Report. II. 1895–1906.
Museum Association.
Annual Report. XXVII, XXVIII. 1907–08.
Book List. I, 2. 1908.
Society of Natural History.
Journal. XXI, 1.
University.
Record. III, 4–VI, 4. 1907–10.

CINCINNATI. University Studies. 2d. Ser. II, 3–4; III, 1, 4; IV, 1–4; V, 1–4. 1906–09.

Observatory, Publications. 16, 1899–1906.

Colorado College.

Publications. General Series. 24, 26, 29–33, 36–37, 39, 42, 44, 45. 1907–09.

Colorado Scientific Society.

Proceedings. IX, 21–344. 1908–10.

COLORADO.—*University of.*

Studies. V, 2–VII, 2. 1908–10.

Connecticut Historical Society.

Annual Report. 1908–09.

COPENHAGEN.—*L'Académie Royale des Sciences et des Lettres de Danemark.*

Bulletin (Oversigt). 1907, 5–1909, 5.

Naturhistoriske Forening.

Videnskabelige Meddelelser. 1907–08.

CORDOVA (Argentine).—*Academia Nacional de Ciencias.*

Boletin. XVIII, 3.

CORUÑA.—*Real Academia Gallega.*

Boletin. I–V, 34, 1906–10.

CRACOW.—*Akademija Umiejętności.*

K. K. Sternwarte. Meteorologische Beobachtungen. Oct., 1906–Feb., 1910.

Resultate der meteorologischen Beobachtungen. 1908–09.

DANZIG.—*Naturforschende Gesellschaft.*

Schriften. Neue Folge. Bd. XII, 3. 1908.

Westpreussischer Botanisch-Zoologischer Verein.

Bericht. XXX, 1908.

DAVENPORT, IA.—*Academy of Sciences.*

Proceedings. XII, 95–222. 1909.

DENISON UNIVERSITY.

Bulletin of the Scientific Laboratories. XIV, 1–XV. p. 100. 1908–10.

DETROIT.—*Museum of Art.*

Annual Report. 1908–09.

Bulletin. III, 1–IV, 1. 1909.

DORPAT.—*Naturforscher-Gesellschaft bei der Universität Dorpat.*

Schriften. XIX. 1909.

Sitzungsberichte. XVI, 2–XVIII, 1. 1907–09.

Gelehrte Estnische Gesellschaft.

Sitzungsberichte. 1906–08.

DRESDEN.—*Naturwissenschaftliche Gesellschaft Isis.*

Sitzungsberichte und Abhandlungen. Juli, 1907–Juni 1909.

DUBLIN.—*Royal Dublin Society.*

Economic Proceedings. I, 12–16 and Index. 1908–09.

DUBLIN. Scientific Proceedings. New. ser. XI, 21–32; XII, 1–23.
Scientific Transactions. Ser. II. IX, 1–9. 1909.
Royal Irish Academy.
Proceedings. XXVII, B, 1–8; C, and appendix. 1908.
DUTCH EAST INDIES.—*K. Natuurkundige Vereeniging.*
Natuurkundige tijdschrift. LXVII–LXVIII. 1908–09.
EDINBURGH.—*Botanical Society.*
Transactions and Proceedings. XXIII, 3–XXIV, 1. 1908–10.
Geological Society.
Transactions. IX, 2–4. 1908–09.
Royal Observatory.
Annals. Vol. II. 1906.
Royal Physical Society.
Proceedings. XVII, 4–XVIII, 1. 1907–10.
Royal Society.
Proceedings. XXVIII. 3. XXX, 4. 1908–10.
ELBERFELD.—*Naturwissenschaftlicher Verein.*
Jahresbericht. IV–XI und Beilage. 1863–1906.
Elisha Mitchell Scientific Society.
Journal. XXIII, 4–XXV, 2. 1908–09.
EMDEN.—*Naturforschende Gesellschaft.*
Jahresbericht. XCI–XCIII. 1905–08.
ERFURT.—*Königl. Akademie gemeinnütziger Wissenschaften.*
Jahrbücher. Neue Folge. Heft XXXII–XXXIV. 1908.
Essex Institute.
Annual Report. 1908–09.
FLORENCE, ITALY.—*Biblioteca Nazionale Centrale.*
Bolletino delle Pubblicazioni Italiane. 88–109. 1908–10.
FRANKFORD, PA.—*Historical Society.*
Papers I. 1–II. 1. 1906–09.
FRANKFURT A. M.—*Deutsche Malakozoologische Gesellschaft.*
Nachrichtsblatt. XL, 2–XLII, 1. 1908–10.
Senckenbergische Naturforschende Gesellschaft.
Abhandlungen. XXIX, 3; XXX, 4. 1908–09.
Bericht. 1908. 1909.
Festschrift zur Erinnerung an die Eröffnung des neuerbauten Museums. 1907.
Verein für Geographie und Statistik.
Jahresbericht I–LXVII, LXX–LXXII. 1836–1908.
FRANKFURT A. O.—*Naturwissenschaftlicher Verein Helios.*
Abhandlungen und Mitteilungen aus dem Gesamtgebiete der Naturwissenschaften. XXIV, XXV. 1908.
Franklin Institute.
Journal. CLXV, 1–CLXIX, 2. 1908–10.
FREIBURG i. B.—*Naturforschende Gesellschaft.*
Berichte. XVII. 1908–09.

GENEVA.—*Institut national genevois.*
Mémoires. XIX. 1901–09.
Société de Physique et d'Histoire Naturelle.
Mémoires. Tome XXXV, 4–XXXVI, 1. 1908–09.

GENOA.—*Museo Civico di Storia Naturale.*
Annali. Ser. 3. III. 1907–08.

GERMANY.—*Kais. Leopoldinisch-Carolinische deutsche Akademie der Naturforscher.* (Halle a. S.)
Leopoldina. XLIII–XLIV. 1907–08.
Abhandlungen. LXXXVIII, 3–XC, 1. 1909.

GIESSEN.—*Oberhessische Gesellschaft für Natur- und Heilkunde.*
Bericht. Neue Folge. Medizinische Abteilung. III–IV. 1908.
Naturwissenschaftliche Abteilung. II. 1907–08.

GLASGOW.—*Natural History Society.*
Transactions. New ser. IV, 1. VIII, 1. 1892–1904; 1905–06.
Journal. I. 1–4. 1908–09.
Royal Philosophical Society.
Proceedings. XXXVIII–XL. 1906–09.

GÖRLITZ.—*Naturforschende Gesellschaft.*
Abhandlungen. V, 1; VIII, XI, XXVI.

GÖTEBORG.—*Kon. Vetenskaps och Vitterhets Samhälle.*
Handlingar. 4de följ. Häft. X–XI. 1901–08.

GÖTTINGEN.—*Königl. Gesellschaft der Wissenschaften.*
Nachrichten. Geschäftliche Mitteilungen. 1908, 1–1909, 2.
Philosophisch-historische Klasse. 1908, 1–1909, 2.

GRAZ.—*Naturwissenschaftlicher Verein für Steiermark.*
Mitteilungen. XLV, 1–2. 1908.

HAARLEM.—*Musée Teyler.*
Archives. Sér. II. XI, 2–3. 1908–09.
Société Hollandaise des Sciences.
Archives néerlandaises. Sér. II. XIII, 3–XV, 5. 1908–09.

HAINAUT.—*Société des Sciences, des Arts et de Lettres.*
Mémoires. Sér. VI, VIII–X. 1906–09.

HAMBURG.—*Deutsche Seewarte.*
Aus dem Archiv. Jahrg. XXIX, 2; XXX, 3; XXXII, 1. 1907–09.
Deutsches meteorologisches Jahrbuch. XXIX–XXXI. 1906–08.
Katalog der Bibliothek. Nachtrag. VIII. 1907–08.
Annalen der Hydrographie und maritimen Meteorologie. XXXVI, 5–XXXVIII, 3. 1908–10.
Jahresbericht. 1907–08.
Naturwissenschaftlicher Verein.
Verhandlungen. 3te Folge. XV–XVI. 1907–08.
Naturwissenschaftliche Gesellschaft.
Jahresbericht. LVII. 1906–07.

Harvard College.—Astronomical Observatory.
Annual Report. LXIII. LXIV. 1909.
Annals. L; LII, 2; LV, 2; LVI, 4; LVIII, 1, 4; LIX, 2, 3, 5; LX, 9; LXI, 2; LXIV, 1–3; LXIX, 1; LXX.
Circulars. No. 136–152.
Museum of Comparative Zoölogy.
Annual Report. 1908–09.
Memoirs. XXXIV, 2–3; XXXVI, 1; XXXVII, 1, 3; XXXVIII, 1. 1908–09.
Bulletin. LI, 11–12; LII, 1–7, 10–14; LIII, 1–4, 6; LIV, 1. 1908–09.
Bulletin. Geological Series. VIII, 7, 9. 1908–09.

Havana.—*Real Colegio de Belen.*
Observaciones meteorológicas y magnéticas. 1907–08.

Havre.—*Société géologique de Normandie.*
Bulletin. XXVI–XXVIII. 1907–08.

Helsingfors.—*Societas Scientiarum Fennica.*
Meteorologisches Jahrbuch für Finland. II. 1902.
Observations publiées par l'Institut Météorologique Central. 1896–98. 1901.
Acta. XXXIII–XXXIV. 1906–08.
Bidrag till kännedom af Finlands natur och folk. Häft 61–66. 1901–08.
Öfversigt af förhandlingar. XLVIII–L. 1905–08.
Societas pro Fauna et Flora Fennica.
Acta XXIV, XXIX–XXXII. 1904–09.
Meddelanden. XXXIII–XXXV. 1906–09.

Hermannstadt.—*Siebenbürgischer Verein für Naturwissenschaften.*
Verhandlungen und Mitteilungen. LVIII. 1908.

Illinois.—*State Laboratory of Natural History.*
Bulletin. VII, 1–10. 1907–09.

India.—*Imperial Department of Agriculture.*
Annual Report. 1905–07.
Report on Progress of Agriculture. 1907–09.
Memoirs. Botanical series. II, 3, 5–8. 1908–09.
Memoirs. Chemical series. I, 6–7. 1908–09.
Memoirs. Entomological series. I, 6–II, 7. 1908.
Agricultural Research Institute (Pusa). Report. 1907–09.
Geological Survey of India.
Memoirs. XXXIV, 4; XXXVI, 2; XXXVII, 1–3. 1908–10.
Records. XXXVIII, 2–3. 1909.
Palæontologia Indica. Ser. XV, V, 1–2; N. S. II, 4–5; III, 3, VI, 3. 1908–09.
Meteorological Department of the Government of India.
Indian meteorological memoirs. XVIII, 2, 4; XIX, 1; XX, 2–7; XXI. 1. 1908–09.

India. Monthly weather review. Feb., 1907 to Nov., 1909.
India weather review. Annual summary. 1906–08.
Rainfall of India. XVI–XVIII. 1906–08.
Report on administration. 1908–09.
Board of Scientific Advice.
Annual report. 1906–09.
Indian Museum.—Records. I, 1–III. 4. 1907–09.
Memoirs. I, 4 and index; II. 1–3. 1909.
Annotated list of Asiatic beetles. I. 1909.
Echinodermata, V. Asteroidea. I. 1909.
Indiana.—*Academy of Science.*
Proceedings. 1907–08.
Constitution. 1887. 1889.
Iowa.—*Academy of Sciences.*
Proceedings. XIV–XV. 1907–08.
State University.
Studies in Psycholoy. II. 1899.
Ireland.—*Pharmaceutical Society.*
Calendar. XXXIV. 1910.
Italy.—*Reale Comitato geologico d'Italia.*
Bolletino. 1907, 1–1910, 1.
Jenaische Zeitschrift für Naturwissenschaft. XXXVI, 3–XXXVIII, 2. 1908–09.
John Crerar Library.
Annual Report. XIII–XIV. 1907–08.
List of books exhibited. Dec. 30, 1907–Dec., 1909.
Johns Hopkins University.
Circular. 1908, 2–1910, 3.
Journal of Comparative Neurology and Psychology.
Vol. XVIII, 1–4. 1907.
Kansas.—*University of Kansas.*
Bulletin. IX, 5. 1908.
Academy of Science.
Transactions. XXII. 1908.
Kasan.—*Société Physico-mathématique de l'Université Impériale.*
Bulletin. Sér. II. XV, 4–XVI, 2. 1906–08.
Kharkoff.—*Société des Sciences Physico-Chimiques.*
Travaux. XXXI–XXXV; Suppl. fasc. XVII, XIX–XXI. 1903–07.
Kiel.—*Kommission zur wissenschaftlichen Untersuchung der deutschen Meere.*
Wissenschaftliche Meeresuntersuchungen, Abt. Kiel. N. F. I, 2; II, 2; III–X, und Erg.-H. VIII & X.
Naturwissenschaftlicher Verein für Schleswig-Holstein.
Schriften. Bd. XIV, 1–2. 1908–10.
Königl. Christian-Albrechts-Universität.
Chronik. 1906–09.

KIEL. Verzeichnis der Vorlesungen. 1906–09.
Dissertations. 1907–09.

KIEV.—*Société des Naturalistes.*
Mémoires. Tome XX, 3. 1908.

KODAIKÁNAL.—*Observatory.*
Bulletin. 12–18. 1908–09.
Annual Report. 1907.
Memoirs. I, 1. 1909.

KOENIGSBERG, i. Pr.—*Physikalisch-ökonomische Gesellschaft.*
Schriften. XLVIII. 1907.

KYOTO.—*Imperial University, College of Science and Engineering.*
Memoirs. I, 4. 1908.

LA PLATA.—*Archivios de Pedagogia y Ciencias Afines.* IV, 10–16 1908–09.
Museo.
Anales. Ser. II, I. 1908.
Revista. XII, 1–2; XIV, 1; XV, 2; XVI. 3. 1905–09.

LA ROCHELLE.—*Académie. Sections des Sciences Naturelles.*
Annales. XXXV. 1906–07.
Flore de France. X–XI. 1907–08.

LAUSANNE.—*Société Vaudoise des Sciences Naturelles.*
Bulletin. 5e sér. XII, 70, 1873; XLIII, 161–XLV, 166. 1907–09.

LEIDEN.—*Nederlandsche Dierkundige Vereeniging.*
Aanwinsten der Bibliotheek. I. 1906–07.
Tijdschrift. Ser. II. Deel X, 4–XI, 2. 1908–09. Register. 1875–1908.

LEIPZIG.—*Königl. Sächsische Gesellschaft der Wissenschaften.*
Berichte. Mathematisch-physische Klasse. LIX, 4; LX, 1–8; LXI, 1–3. 1907–09.
Fürstl. Jablonowskische Gesellschaft.
Jahresbericht. 1908.
Naturforschende Gesellschaft.
Sitzungsberichte. 1899–1906.
Verein für Erdkunde.
Mitteilungen. 1906. 1907.

LEMBERG.—*Société Royale des Sciences.*
Mémoires. Sér. III. VII–VIII. 1907. 1909.
Math.-Naturw.-Aerztl. Section. Sammelschrift. XII. 1908.

LINZ.—*Museum Francisco-Carolinum.*
Jahresbericht. 3, 5–7, 11, 20, 21, 29, 33, 35, 37, 38, 40, 42, 43, 46–68.

LISBON.—*Sociedade de Geographia.*
Boletim. Serie XXVI, 1–XXVII, 2. 1908–09.
Memorias do Ultramar. Viagens, explorações e conquistas dos Portuguezes, por Luciano Cordeiro.
Leite de Vasconcellos, J., Estudos de philologica. I–II. 1901.

Lisbon. Sa, A. de. Frei Gonçalo Velho. I–II. 1900.
Esteves Pereira, F. M., Chronica de Susenyos, rei de Ethiopia. I–II. 1892.
Sessão solemne. 16 May, 1898.
Sixty one miscellaneous monographs.

London.—*Geological Society.*
Geological Literature added to the Library. 1908.
Quarterly Journal. LXIII, 1–LXV, 260. 1907–09.

Linnean Society.
Journal. Zoölogy. 197–200, 204–06. 1907–09.
Journal. Botany. 265–71. 1908–09.
List. 1908–10.
Proceedings. CXX–CXXI. 1908–09.

Royal Geographical Society.
Grenfell, G. Upper Congo (map). 1902.
Grundy, G. B. Battle of Platæa. 1894.
Guenther, R. T. Bibliography of topographical and geological works on the Phlegræan Fields, 1908.
McCarthy, J. Surveying and exploring in Siam. 1900.
Merzbacher, G. Central Tian-Shan Mountains. 1905.
Murray, G. & Markham, C. R. Antarctic manual for 1901.
Murray, J. & Pullar, L. Bathymetrical survey of the fresh water lochs of Scotland. 1908.
Murray, J. & Peake, R. E. Floor of the Atlantic Ocean. 1904.
Peake, R. E. Deep-sea sounding expedition in the North Atlantic. 1901.
Selection of papers on arctic geography and ethnology (reprinted). 1875.
Smyth, H. W. The Upper Mekong, Siam. 1895.
Stein, M. A. Mountain panoramas from the Pamirs and Kwen Lun. 1908.

Royal Society.
Philosophical Transactions. Series A. 128–60. 1908–09.
Series B. 260–72. 1908–09.
Proceedings. Series A. 538–62. 1908–10.
Series B. 537–54. 1908–10.

Royal Microscopical Society.
Journal. 1908, 2–1909, 6.

Royal Geographical Society.
Geographical Journal. XXXI, 5–XXXV. 2. 1908–10.
Karakorum Himalayas by W. M. Conway. I–II. 1892.

Mathematical Society.
Proceedings. VI–VIII, 2. 1908–10.
List of members. 1908.

Louisiana.—*State Board of Agriculture and Immigration.*
Gulf Biological Station.

Louisiana. Bulletin. 8, 13, 14.

Lucca.—*R. Accademia Lucchese di Scienze, Lettere ed Arti.*
Atti. XXXIII. 1907.

Lund.—*Kongl. Carolinska Universitet.*
Acta. N. F. II–IV, 1; VI, 2. 1906–08.

Luxembourg.—*Institut Grand-Ducal.*
Archives trimestr. N. S. II–III. 1907–08.

Lyons.—*Société d'Agriculture, Sciences et Industrie.*
Annales. 1907–08.

Université.
Annales. Science-Médecine. N. S. I, 22–24. 1908.
Société des Amis de l'Université. XX, 1–2; XXI, 1–6; XXII, 1–7. 1907–09.

Madrid.—*Observatorio Astronomico.*
Anuario. 1909–10.

R. Academia de Ciencias exactas, fisicas y naturales.
Memorias. XXVI. 1908.
Revista. VII, 1–VIII, 3, 6. 1908–10.

R. Academia de la Historia.
Cortes de los antiguos reinos de Aragon. XII. 1908.
Boletin. XLIV, 1; LIII, 3. 1904–08.
Memorial historico español. XXXVII–XLIII. 1898–1905.

Magdeburg.—*Naturwissenschaftlicher Verein.*
Jahresbericht. III, V, VII, IX, 1872–82.
Jahresbericht und Abhandlungen. 1886–1907. (14 numbers.)
Festschrift. 25. 1894.

Museum für Natur- und Heimatkunde
Abhandlungen und Berichte. I, 1–4. 1909.

Manchester (England).—*Geographical Society.*
Journal. XXVI. 1909.

Literary and Philosophical Society.
Memoirs and Proceedings. LII, 2–LIV, 1. 1907–09.

University.
Publications. Anatomical series, I, 1906; Historical series, I–VI, VIII, 1904–09; Medical series, I–VII, X–XII, 1904–09; Physical series, I, 1906.
Owen's College. Studies in Anatomy, II, 1900; Studies from the Biological Laboratory, IV, 1899; Studies from the Physical and Chemical Laboratories, I, 1893.

Manchester, N. H.—*Institute of Arts and Sciences.*
Proceedings. IV, 2. 1909.

Marburg.—*Gesellschaft zur Beförderung der gesamten Naturwissenschaften.*
Sitzungsberichte. 1907–08.

Mecklenburg.—*Verein der Freunde der Naturgeschichte in Mecklenburg.*
Archiv. LXI, 2–LXIII, 1. 1907–09.

MELBOURNE.—*National Museum.*
Memoirs. 2. 1908.

METZ.—*Académie.*
Mémoires. XXXIV–XXXV. 1904–06; Table générale. 1819–1903.

MEXICO.—*Instituto Geológico de México.*
Boletin. 17, 24. 26. 1908.
Parergones. II, 1–III, 2. 1908–09.

Instituto Médico Nacional.
Anales. VIII–X. Oct., 1906–May, 1908.

Observatorio Astronómico Nacional de Chapultepec.
Anuario. Tome XXIX–XXX. 1909–10.

Observatorio Meteorológico Central.
Boletin mensual. Nov., 1907–April, 1909.

Observatorio de Tacubaya y Guajimalpa.
Observaciones meteorológicas. Año de 1909.

Sociedad Científica "Antonio Alzate."
Memorias y revista. XXV, 9, 12; XXVI, 1–XXVII, 3. 1908–09.

MICHIGAN, *University of.*
Field Studies in Botany. University Bulletin. N. S. VII, 5, 9, 10, 14–15.

MICHIGAN.—*Academy of Sciences.*
Report. XI. 1909.

MIDDELBURG.—*Zeeuwsch Genootschap der Wetenschappen.*
Archief. 1908. 1909.

MILAN.—*Real Istituto Lombardo di Scienze e Lettere.*
Rendiconto. Serie II. XL, 16–XLII, 15. 1908–09.

Reale Osservatorio di Brera.
Publicazioni. XL, 2. 1908.

Società Italiana di Scienze Naturali.
Atti. XLVI, 1–XLVIII, 3. 1908–09.
Strambio, G. Jr. La pellagra. 1890.

MILWAUKEE.—*Public Museum.*
Annual Report. I, V, VII–XVI. 1883–1908.

MISSOURI.—*Botanical Garden.*
Annual Report. XIX–XX. 1908–09.

University of Missouri.
Law's Observatory. Bulletin. 13–16. 1908.

MODENA.—*R. Accademia delle Scienze, Lettere et Arti.*
Memorie. Ser. II. Tome XII.
Ser. III. Tome VII.

Società dei Naturalisti e Matematici.
Atti. Rendiconti. Ser. IV, vol. VII–X. 1905–08.

MOLDAUTEIN.—*Export-Verein für Böhmen.*
Jahresbericht. XV. 1906.

MONACO.—*Institut Océanographique.*
Annales. I, 1. 1910.

MONTANA.—*College of Agriculture and Mechanical Arts.*
Bulletin. V, 3. 1908.

Agricultural Experiment Station (Bozeman).
Annual report. XIV, XV. 1907–08.
Bulletin. 69, 71–74, 76. 1908–09.

University (Missoula).
Bulletin. 46, 50–51, 54, 58. 1908–09; Geological ser. 8, 11–13; Psychological ser. 1. 1908.

MONTEVIDEO.—*Museo Nacional.*
Anales. Tome IV, 1. 1909.

Observatorio Nacional Físico-Climatológico.
Boletin. VI, 55–60, 62, 64, 66, 69–72. 1908–09.

MONTPELLIER.—*Académie des Sciences et Lettres.*
Mémoires. Section des lettres. Sér. II. V, 1. 1908.
Section des sciences. Sér. II. III, 3. 1908.
Section de médecine. Sér. II. II, 3. 1907.
Bulletin mensual. 1907, 3–7; 1910, 3.

MOSCOW.—*Königl. Universität, Meteorologisches Observatorium.*
Beobachtungen. 1905–07.

Société Impériale des Naturalistes.
Bulletin. 1–4. 1907.

MUNICH.—*Königl. Bayerische Akademie der Wissenschaften.*
Sitzungsberichte. Mathematisch-physikalische Klasse. 1908. 1–3; 1909. 1–14.
Philosophisch-historische Klasse. 1908. 1–11.
Abhandlungen. Mathematisch-physikalische Klasse. Suppl. I. 1–II. 1; XXIII. 3; XXIV. 2. 1908–09.
Phil.-hist. Klasse. XXIII. 3; XXIV. 3; XXV. 1. 1909.

Königl. Sternwarte.
Neue Annalen IV und Supplementheft. I. 1907–10.

MÜNSTER, i. W.—*Westfälischer Provinzial-Verein für Wissenschaft und Kunst.*
Jahresbericht. XXXV–XXXVII. 1906–09.

Mycological Notes.
27–28. Polyporoid issue, I. 1907–08.

NANCY.—*Académie de Stanislas.*
Mémoires. 6e sér. V, 1907–08.

NAPLES.—*R. Istituto d'Incoraggiamento alle Scienze Naturali.*
Atti. Ser. VI. LIX–LX. 1907–08.

R. Università.
Annuario del Museo Zoologico. N. S. Vol. II, 17–27. 1908.
Centenario della cattedra di Zoologia. 1806–1906. 1907.

R. Accademia di Scienze Morali e Politiche.
Atti. Vol. XXXVIII. 1909.

NAPLES. Rendiconto. XLV–XLVII. 1906–08.

R. Accademia delle Scienze Fisiche e Matematiche.

Rendiconto. Ser. III. XIV, 1–12; XV, 1–7. 1909.

Atti. Ser. III. XIII–XIV. 1908–09.

NATAL.—*Government Museum* (Pietermaritzburg).

Annals. I, Index; II, 1. 1909.

National Academy of Sciences (Washington).

Biographical Memoirs. VI. 1910.

National Physical Laboratory (Teddington).

Collected researches. II–V.

Report. 1908.

Naturae Novitates.

1908, 1–17; 1909, 1–19.

NEBRASKA.—*Academy of Science.*

Publications. VIII, 3. 1907.

NEUCHATEL.—*Société Neuchateloise des Sciences Naturelles.*

Bulletin. XXXIII. 1904–05; XXXV. 1907–08.

Académie.—Recueil de Travaux, Faculté des lettres. 2–4. 1907–08.

NEW BRUNSWICK, N. S.—*Natural History Society.*

Bulletin. XXVI. VI, 1–2. 1908–10.

NEW SOUTH WALES.—*Linnean Society.*

Proceedings. Ser. II. XXXII, 4–XXXIV, 2. 1907–09.

Royal Society.

Journal and Proceedings. XLI. XLIII. 1. 1907–08.

NEW YORK.—*Academy of Sciences.*

Annals. XVIII, 2–XIX, 1. 1908–09.

Directory. 1907–10.

Botanical Garden.

Bulletin. VI, 18, 19, 20; VII, 24. 1908–10.

Microscopical Society.

Journal. X. 1–XI. 1, 3–XIV. 1, XV. 2, XVI, 1–3.

Public Library.

Bulletin. XII, 4–XVI, 3. 1908–10.

State Museum.

Annual Report. LX, 1–5; LXI, 1–4. 1907–08.

Memoirs. V, VI, 2; VII, 1; VIII, 1–2; IX, 1; X.

NEW ZEALAND.—*Institute.*

Transactions and proceedings. N. S. XL–XLI. 1908–09.

NEWCASTE-UPON-TYNE.—*North of England Institute of Mining and Mechanical Engineers.*

Transactions. LVII, 7; LVIII, 3; LIX, 3–8. 1908–09.

Subject-matter index of mining, mechanical and metallurgical literature for 1902.

Annual report of the council. 1908–09.

Norfolk and Norwich Naturalists' Society.

Transactions. VII–VIII. 5.

NORTH DAKOTA.—*Geological Survey.*
Biennial report. II–V. 1901–08.
State Historical Society.
Collections. I–II. 1906–08.

NOVA SCOTIA.—*Department of Mines.*
Report. 1907–09.

NUREMBERG.—*Naturhistorische Gesellschaft.*
Abhandlungen. XVII und Beigabe 1909.
Mitteilungen. 1907, 1–6; 1908, 1.

Oberlin College.
Laboratory Bulletin. 14–15. 1909.

ODESSA.—*Société des Naturalistes de la Nouvelle-Russie.*
Mémoires. XXX–XXXIII. 1907–09.

OHIO.—*State Academy of Science.*
Proeeedings. V, 2–5. 1908–10.
Geological Survey.
Bulletin. 8–9. 1908.

OKLAHOMA.—*Geological Survey.*
Bulletin. 1. 1908.
State University.
Bulletin. 1–2. 1910.
Research Bulletin 142.

OXFORD.—*Radcliffe Library.*
Catalogue of Books added. 1908, 1909.
University Observatory.
Astrographic Catalogue. III–IV. 1900.

PAISLEY.—*Philosophical Institution.*
Annual Report. XCI–CI. 1899–1909.
Coats Observatory. Meteorological Observations. 1898–1908.

PALERMO.—*R. Accademia di Scienze, Lettere e Belle Arti*
Bolletino. 1903–06.
Società di Scienze Naturali ed Economiche.
Giornale di scienze naturali ed economiche. XXVI–XXVII. 1908–09.

PARIS.—*Ecole Polytechnique.*
Journal. 2e sér. Cahier XI. 1907.
Musée Guimet.
Annales. Bibliothèque d'études. Tome XXIV–XXV. 1907–08.
Musée d'Histoire Naturelle.
Bulletin. Année 1907, 6–7; 1909, 5.
Société Zoologique de France.
Mémoires. XIX–XXI. 1906–08.
Bulletin. XXXI–XXXIII. 1908–09.
Observatoire.
Rapport annuel. 1907–08.

PASADENA.—*Throop Institute.*
Bulletin. 40. 42. 1908–09.
Pathologica, Revista quindecinal. I. 19–34. 1909–10.
PERU.—*Ministerio de Fomento.*
Cuerpo de Ingenieros de Minas.
Boletin. 41, 44–54, 56–74. 1908–09.
PHILADELPHIA.—*Academy of Natural Sciences.*
Journal. 2d ser. XIII, 4–XIV, 1. 1908–09.
Geographical Society.
Bulletin. IV, 3–V, 2; VI, 2–VIII, 1.
Photographic Journal. Febr. 1910.
PISA.—*Società Toscana di Scienze Naturali.*
Memorie. XXIII–XXIV. 1908–09.
Processi verbali. XVII, 3–XVIII, 6. 1910.
PITTSBURGH.—*Carnegie Institute.*
Memorial of Celebration (Founder's Day). XIII. 1909.
Carnegie Library.
Annual Report. X–XI. 1906–07.
Carnegie Museum.
Publications. 50–51, 52, 54, 56–59. 1908–09.
POMONA COLLEGE.
Pomona Journal of Entomology. I, 1.
PORTICI.—*R. Scuola Superiore di Agricoltura.*
Annali. 2ª Ser. VIII. 1908.
PORTLAND, Me.—*Society of Natural History.*
Proceedings. II, 8. 1909.
POTSDAM.—*Astrophysikalisches Observatorium.*
Publikationen. XV, 1; XVIII, 2–3; XIX, 1–2; XX, 4. 1908–09.
PRAGUE.—*Königl. Böhmische Gesellschaft der Wissenschaften.*
Jahresbericht. 1908.
Sitzungsberichte. Mathematisch-naturwissenschaftliche Klasse. 1908.
Generalregister der Schriften. 1884–1904.
K. K. Sternwarte.
Magnetische und meteorologische Beobachtungen. 1907–08.
Česká Společnost Entomologičká. I, 1–VI, 4. 1904–09.
Deutscher naturwissenschaftlich-medizinischer Verein für Böhmen „Lotos".
Abhandlungen. I, 2-3. II, 1–4.
Naturwissenschaftliche Zeitschrift. XVIII–XXVI, 1898–1907.
QUEBEC.—*Société de Géographie.*
Bulletin. Jan., July, 1908; III, 4–IV. 1. 1908–10.
Queensland Geographical Journal.
N. S. XXIII–XXIV. 1907–09.
QUEENSLAND.—*Museum* (Brisbane).
Annual Report. 1878, 1883, 1887–89, 1891, 1893–94, 1899, 1901.

QUEENSLAND. Annals. 3, 8–9. 1897–1909.

REGENSBURG.—*Historischer Verein von Oberpfalz und Regensburg.*
Berichte. XI. 1905–06.
Verhandlungen. 1906–08.

RIGA.—*Naturforscher-Verein.*
Arbeiten. N. F. XI. 1908.
Korrespondenzblatt. L–LII. 1907–09.

RIO DE JANEIRO.—*Instituto Oswaldo Cruz.*
Memoria. I. 1–2. 1909.
Museo Nacional.
Archivios. I–VI. 1876–85

Rockefeller Institute of Medical Research.
Studies. VI. 1909.

Roentgen-Society.
Journal. I–V, 22.

ROME.—*R. Accademia dei Lincei.*
Atti. Serie V. Rendiconti. Classe di scienze fisiche, matematiche e naturali. XVII, 5–XIX. 5. 1908–10.
Rendiconto dell'adunanza solenne. 1908, II; 1909, II.
Accademia Pontifica de' Nuovi Lincei.
Atti. LXI–LXII. 1908–09.
Società Italiana delle Scienze.
Memorie di Matematica e di Fisica. Serie III. Tom. XV. 1908.

ST. LOUIS.—*Academy of Science.*
Transactions. XVII, 2–XIX, 1. 1908–09.

ST. PETERSBURG.—*Académie Impériale des Sciences.*
Bulletin. Classe Phys.-Math. Sér. V. XXV, 3–5; Sér. VI. 1908, 2–18; 1909, 1–18; 1910, 1–5.
Mémoires. Classe Phys.-Math. Sér. VIII. XVII, 1–7; XVIII, 1–13; XIX, 1–11; XX, 1–11; XXI, 1–3; XXII, 1–10; XXIII, 1–6. 1905–08.
Mémoires. Classe Hist.-Philol. Sér. VIII. Tome VIII, 1–12. IX, 1. 1906–09.
Radloff, W. Versuch eines Wörterbuchs der Türk-Dialecte. Lieferung 1, 2, 4–6, 12–16, 19–21.
Hortus Petropolitanus.
Acta. XXVII, 2; XXVIII, 1–2; XXIX, 1–2; XXX, 1. 1908–1909.
Comité Géologique.
Bulletin. XXV, 10; XXVI, 1–10; XXVII, 2–10. 1907–08.
Mémoires. Nouv. sér. Liv. 22, 28, 30, 32, 34, 36–38, 41–50. 1908.
Imp. Russ. Geograf. Obshtchestvo.
Izviestiïa. XLII, 4–5; XLIV, 1–3, 5–6, 8, 10; XLV, 10. 1906–09.
Otchet. 1908.

ST. PETERSBURG.—*Kaiserlich-Russische Mineralogische Gesellschaft.*
Materialien zur Geologie Rußlands. XXIII, 2; XXIV, 1–2. 1908–09.
Verhandlungen. Ser. II. XLV–XLVI. 1907–08.
Observatoire Physique Central Nicolas.
Annales. 1905, 1–1906, 2.
Publications. Sér. II. XVI, 1; XVIII, 2, 4. 1908–10.
Société du Chemin de Fer Chinois de l'Est.
Observations météorologiques en Mandchourie. I. 1909.
SANTIAGO DE CHILE.—*Sociedad Científica de Chile.*
Actes. XVII, 1–XVIII, 5. 1907-08.
SAÕ PAULO.—*Museu Paulista.*
Notas preliminares. I, 1. 1907.
Revista do Museu. II, VII.
Sociedade Scientifica.
Revista. II–III. 1907–08.
Schweizerische Naturforschende Gesellschaft.
Verhandlungen. LXXVIII–XCI, 2. 1895–1908.
SIENA.—*R. Accademia dei Fisiocritici.*
Atti. Ser. IV. XX, 1–10. Serie V. I, 1–10. 1908–10.
Smithsonian Institution.
Bureau of American Ethnology.
Annual Report. XXVI. 1904–05.
Bulletin. 35, 38, 41, 42, 48. 1908–09.
National Museum.
Bulletin. 64–66. 68, 70. 1908–09.
Proceedings. XXXIV–XXXVI. 1908–09.
Contributions from National Herbarium. X, 7; XII, 1–10. XIII. 2. 1908–10.
Report on Progress and Condition. 1908–09.
SOUTH AFRICA.—*Philosophical Society.*
Transactions. XIII, pp. 1–752; XIV, 1–XVIII, 4.
Royal Society.
Transactions. I, 1–2. 1909–10.
South London Entomological and Natural History Society.
Abstract of Proceedings. 1886–1909.
STATEN ISLAND, N. Y.—*Natural Science Association.*
Proceedings. I, 1–4 and table of contents; II, 1–2; Proceedings, 25th anniversary.
Museum Bulletin. 1 and Suppl. 2–20.
STOCKHOLM.—*Kongl. Svenska Vetenskaps-Akademi.*
Arkiv för Botanik. VII, 1–4; IX, 1. 1908–09.
Arkiv för Kemi, Mineralogi och Geologi. III, 1–3. 1908–10.
Arkiv för Matematik, Astronomi och Fysik. IV, 1–V, 4. 1908–09.
Arkiv för Zoologi. IV, 1–4; V, 4. 1908–10.

STOCKHOLM.—Årsbok. 1908–09.
Handlingar. Ny följd. XLII, 10–XLIV, 5; XLV, 2. 1908–10.
Lefnadsteckningar. IV, 4. 1910.
Meteorologiska Iakttagelser i Sverige. XLVIII–L. 1906–08.
Meddelanden från Nobelinstitut. I, 8–10, 12–13, 15. 1908–10.
Les prix Nobel en 1906.
Observations météorologiques suédoises. Vol. XLVIII. 1906.
Kongl. Bibliotek.
Accessions-katalog. XXII. 1907.
Årsberättelse. 1907–08.
Entomologisk Förening.
Entomologisk Tidskrift. XXIX–XXX, 4. 1908–09.
Kgl. Forstliche Versuchsanstalt.
Meddelanden. Häft 6. 1909.
STRASSBURG, i. E.—*K. Universitäts-Sternwarte.*
Annalen. III. 1909.
STUTTGART.—*Verein für vaterländische Naturkunde in Württemberg.*
Jahreshefte. LXIV–LXV, und 4 Beilagen. 1908–09.
TASMANIA.—*Royal Society.*
Papers and Proceedings. 1908.
TEXAS.—*Academy of Science.*
Transactions. I, 3–4; II, 1–2; IV; VI–VIII; X. 1895–1907.
University of Texas.
Bulletin. 102–103, 106–109, 114–117, 119–120, 123, 125.
Hill, B. F. and Udder, F. A. Map of West Texas. 1904.
Bulletin. Reprint series. 2, 5, 7, 8. 1906–09.
TIFLIS.—*Physikalisches Observatorium.*
Seismische Monatsberichte. 1906, 10–1908, 12.
TOKYO.—*Deutsche Gesellschaft für Natur- und Völkerkunde Ostasiens.*
Mitteilungen. V. Suppl. XII. 1889, 1909.
Imperial University of Japan.
Journal of the College of Science. XXVI, 2; XXVII, 3–6. 1909.
Calendar. 1907–08.
TORONTO.—*University.*
Publications. Biological series. 4–7. 1908.
Geological series. 3–5. 1908.
Physiological series. 4–7. 1908–09.
TOULOUSE.—*Académie des Sciences, Inscriptions et Belles-Lettres.*
Mémoires. Xe sér. Tome VII–VIII. 1908–09.
Faculté des Sciences de l'Université.
Annales. 2e sér. IX, 2–X, 2. 1907–09.
Société d'Histoire Naturelle.
Bulletin trimestr. XL, 1–XLII, 2. 1907–09.
Université.
Annuaire. 1907 10.
Bulletin. 18–20. 1906–08.

Toulouse. Bulletin populaire de la pisciculture. II. 5–8. 1909.
Observatoire. Bulletin. II, 1–2. 1907–08.

Triest.—*Osservatorio Maritimo.*
Rapporto annuale. 1904–05.

Tromsoe.—*Museum.*
Aarsberetning. 1906–07.
Aarshefter. 25, 29. 1902, 1906.

Trondheim.—*Kongl. Norske Videnskabers Selskab.*
Skrifter. 1907–08.

Tufts College.
Studies. Scientific series. II, 3. 1909.

Turin.—*Musei di Zoologia ed Anatomia Comparata.*
Bollettino. XXI, 541; XXII, 546–76; XXIII, 576–95; XXIV, 596–615. 1908–10.

United States.—*Department of Agriculture.*
Crop Reporter. X, 5–XI, 3; XI, 7–XII, 4. 1908–10.
Bulletin of the Library. 66–75. 1908–09.
Monthly List of Publications. April 1908, to Jan., 1910.
Bulletin of the Mt. Weather Observatory of the Weather Bureau. Vol. I, 2–II, 3. 1908–10.
Report of the Chief of the Weather Bureau. 1906–07.
Weather Bureau. Bull. Q.

Department of the Interior.
Ethnological Bureau. Bulletin. 34. 1909.
Geological Survey. Bulletin. 309, 316, 319, 321–22, 325–27, 329–36, 338–42, 344–52, 355, 357–60, 362–63, 369, 373, 377, 380, 383, 384, 387–93, 395–7, 399, 400, 402–05, 408–09, 410–14, 416, 418–19, 421, 423–24.
Geologic Atlas of the United States. Fol. 151–66.
Mineral Resources of the United States. 1907–08.
Monographs. XLIX. 1908.
Professional Papers. 56, 58–67. 1908–10.
Annual Report. XXVIII–XXX. 1907–09.
Water-supply and irrigation papers. 207, 209–36, 238, 242.

Library of Congress.
Select List of Books on Sugar. 1910.
Report of Librarian and Superintendent of Buildings and Grounds. 1908–09.

Naval Observatory.
Synopsis of the Report of the Superintendent. 1909.

Upsala.—*Regia Societas Scientiarum.*
Nova Acta. Ser. IV, Vol. II, 1. 1909.

Kongl. Universitet.
Årsskrift. 1908.

Geologiska Institution.
Bulletin. VIII, 15–16. 1906–1907.

URUGUAY.

Annuario estadístico. 1907–08, 1.

UTRECHT.—*Kon. Nederlandsch Meteorologisch Instituut.*

Jaarboek. Jahrg. 1906, A–B. 1907, A–B.

Mededeelingen en Verhandlingen. CII, 1908, A–B. 6–7, 9. 1908–10.

Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen.

Aanteekeningen van het verhandelde in de sectie-vergaderingen. 1908–09.

Observatoire.

Recherches astronomiques. III. 1908.

VENICE.—*R. Istituto Veneto di Scienze, Lettere et Arti.*

Atti. LXV, 1–LXVII, 5.

Elenco dei membri e soci. 1907–08.

Osservatorio del Seminario Patriarcale. Osservazioni meteorologiche e geodinamiche. 1906.

VICENZA.—*Accademia Olimpica.*

Atti. N. S., I, 1907–08.

VIENNA.—*K. K. Akademie der Wissenschaften.*

Anzeiger. Math.-naturwiss. Klasse. XXV–XXXI, XXXIII–XXXV–XXXVII, 8, XLVI–XLVIII. 1888–1909.
Phil.-hist. Klasse. XVII–XX, XXII–XXV, XXVII–XXIX, XXXIX–XLV. 1880–1908.

Denkschriften. Math.-naturw. Klasse. LIX–LXVI, 3; LXXI, 1; LXXII–LXXIV; LXXVII–LXXIX, 1; LXXX–LXXXI.

Sitzungsberichte. Math.-naturwiss. Klasse. CXIV, 9–CXVI, 10; CXVII, 8–10; CXVIII, 1–7. 1905–09.
Phil.-hist. Klasse. CXVII, 1–7, CXLV–CLIV.

Allgemeine Berichte. Officielle Publikation. III–IV. 1908–09.

Almanach. 1902–07.

Erdbeben-Commission. Mitteilungen. N. F. XXVII, XXXIII–XXXV. 1908–09.

K. K. Reichsanstalt.

Abhandlungen. XVI, 2; XXI, 2. 1908–09.

Jahrbuch. LVII, 4–LIX, 2. 1908–09.

Verhandlungen. 1907, 15–18; 1908, 2–18; 1909, 1–14.

K. K. naturhistorisches Hofmuseum.

Annalen. XXI, 3–XXIII, 3. 1906–09.

Universitäts-Sternwarte.

Annalen. XIX, XX.

Verein zur Verbreitung naturwissenschaftlicher Kenntnisse in Wien.

Schriften. XV, XVI, XVIII, XX–XXIII, XXV, XXVII–XXVIII, XXX, XXXII–XLIX.

K. K. Zentral-Anstalt für Meteorologie und Geodynamik.

Jahrbücher. N. F. Bd. XLII. 1905.

VIENNA.—*K. K. Zoologisch-Botanische Gesellschaft.*
Verhandlungen. Bd. LVII, 1—LVIII, 10. 1907–08.
Warren Academy of Sciences.
Annual Report. 1907–08.
Transactions. I, 1. 1903–07.
WASHINGTON.—*Philosophical Society.*
Bulletin. XV, 75–187. 1908–09.
WESTERN AUSTRALIA.—*Department of Mines.*
Reports (5). 1909.
Geological Survey.
Bulletin. 27–30, 32, 35, 37.
WIESBADEN.—*Nassauischer Verein für Naturkunde.*
Jahrbücher. LXI—LXII. 1908–09.
Wilson Ornithological Club.
Wilson Bulletin. 62–69. 1908–09.
WISCONSIN.—*Academy of Sciences, Arts and Letters.*
Transactions. XV, pt. 2—XVI, pt. 1, no. 6. 1907–08.
Geological and Natural History Survey.
Bulletin. Suppl. map. XIV.
Natural History Society.
Bulletin. New ser. V, 4—VII, 2. 1907–09.
Road Pamphlet. 1–4. 1908.
University of Wisconsin.—Washburn Observatory.
Publications. XII. 1902–07.
WÜRZBURG.—*Physikalisch-medicinische Gesellschaft.*
Sitzungsberichte. 1907, 1908, 6.
Wyoming Historical and Genealogical Society.
Proceedings and collections. X. 1909.
Medal commemorating the Centennial of the first use of Wyoming coal.
ZÜRICH.—*Naturforschende Gesellschaft.*
Vierteljahrsschrift. LII, 3—LIV, 2. 1907–09.

FROM THE AUTHORS AND PUBLISHERS.

Agassiz, A. Address, opening geological section of Harvard University Museum. 1902.

James, W. Louis Agassiz, address, reception of American society of naturalists. Dec. 30, 1896, 1897.

Leyst, E. Höfe um Sonne und Mond in Rußland. Moscow, 1906.

Luftelectrische Zerstreuung und Radioactivität in der Höhle Bin-Basch-Choba in der Krim. 1906.

Meteorologische Beobachtungen in Moskau. 1905, 1906.

Über Schätzung der Bewölkungsgrade. 1906.

Das Erdbeben von San Francisco. 1906.

New York, Duchess County. Book of supervisors, 1718–22. Poughkeepsie.

Thomson, T. A. and Simpson, T. T. Account of Alcyonarians. Indian Marine Service Ship "Investigation." II. 1909.

INDEX.

Acolastus, 380, 381, 382.
Active life, the, 339–40.
Adam Praemonstrateus, 326.
Ælfric, 304.
Alain de Lille, 297, 300, 326, 377.
Albion Knight, 372.
All for Money, 346, 387.
Alphabet of Tales, *An*, 297, 300, 301, 302, 305, 310.
Amphitruo, 384, 399.
Ane Satyre of the Thrie Estaits, 370–71, 390, 393.
Antichrist, the legend of, 346–51; as a source of the moral plays, 350–51.
Anticlaudianus, 326.
Appius and Virginia, 399–400.
Aristotle, 360, 383.
Asotus, 380.
Assembly of Gods, *The*, 328.
Augustine, 294, 297, 304, 307, 339.
Bale, 361–64, 367, 369.
Bataille d'Enfer et de Paradis, 343.
Bataille de Karesme et de Charnage, 343.
Bataille des Sept Arts, 342.
Bataille des Vices contre les Vertus, 327.
Bede, 304.
Bernard, 295, 304, 307, 310, 330, 331, 339, 355.
Besançon, Étienne de, 300. See *Alphabet of Tales*.
Biblia Pauperum, 302.
Bien-Avisé, Mal-Avisé, 359.
Blickling Homilies, *The*, 304, 306, 310.
Blois: see Peter of Blois.
Bonaventura, 302, 356.
Bourbon, Étienne de, 300, 301, 302.
Bozon, 310.
Brandt, 360.
Burning of John Huss, *The*, 369.
Calisto and Melibœa, 398.
Cambyses, 400, 401.
Captivi, 383.
Castle of Perseverance, *The*, 312–20, 336, 337, 354, 358, 389–90, 393, 394.
Chasteau d'Amour, 335, 356.
Cheke, 369.
Cobler's Prophecie, *The*, 346, 400–401.
Collection of Letters, *Statutes*, *and Other Documents*, *A*, 374.
Colloque Social, 358.
Condamnation des Banquets, 359, 397.
Conflict of Conscience, *The*, 367.
Contract of Marriage between Wit and Wisdome, *The*, 379.
Controversial moral plays, 359–75.
Creed plays, the, 334–38.
Cursor Mundi, 336, 356.
Cyprian, 321, 329.
Dance of Death, the, its general treatment, 341, 351–54; in English moral plays, 352–54; in French moralities, 354.
De Conflictu Vitiorum et Virtutum, 328.
De Eruditione Praedicatorum, 298.
De Meretrice Babylonica, 374.
De Nuptiis Philologiae et Mercurii, 380.
De Patientia, 309.
De Tribus Dietis, 359.
Debate, literature of, in Middle Ages, 341–46, 354; in Reformation times 365–67.
Debate: see Psalms, 85. 10.
Debate between the Body and the Soul, 341, 345, 354.
Debate of the Carpenter's Tools, 344.

Devil, the, on the stage, 395–97. 401–402.
Dialogue: see Debate.
Disobedient Child, The, 382.
Échecs Amoureux, Les, 379.
Endightment against Mother Messe, The, 366.
Enterlude of John Bon & Mast Person, The, 369.
Ephraem, the Syrian, 321.
Everyman, 341, 352–53, 390.
Exempla, 299–304.
Farces, Influence on moral plays, 388–89. See Heywood.
Freedom of the will, 317–18.
Freewill, 369.
Fulwel, 388.
Gammer Gurton's Needle, 401.
Gascoigne, 384.
Glasse of Gouernement, 384–86.
Glossa Ordinaria, 334.
Gnapheus, 380.
God's Promises, 369.
Godly Queen Hester, 371.
Golden Legend, The, 367.
Greban, 356.
Gregory, the Great, 295, 296, 297, 300, 301, 330.
Grosseteste, 296, 335, 341, 356.
Hamartigenia, 322, 329, 330.
Heywood, 345–46, 389.
Hickscorner, 382, 388.
Homilaria, 296–99.
Honneur des Dames, 332, 359.
Honorius of Autun, 296, 297, 298, 305, 377.
Hugo of Saint Victor, 310, 330, 331, 334, 355.
Humanism: see Renaissance.
Humbert de Romanis, 298, 299.
Huon de Méri, 326.
Ingeland, 381.
Jack Juggler, 384, 399.
Jacques de Vitry, 298, 299, 300, 301, 305, 313.
Jonson, 401–402.
King Cambyses, 400, 401.
King Darius, 346.
King John, 362–64, 367.
Kirchmayer, 366, 367, 374.
Lactantius, 321.
Legal regulation of moral plays, 364, 373–75.
Liberality and Prodigality, 332, 383, 395, 397.
Life and Death of Mary Magdalene, 388.
Like Will to Like, 346, 388, 394.
Lindsay, 370.
Longer Thou Livest, The, 398.
Lord Governaunce, 373.
Lord's Prayer, the, as interpreted in the Middle Ages, 334; as connected thereby with the *Psychomachia*, 334; the Pater Noster plays, 334–38.
Ludus de Antichristo, 350–51.
Lupton, 387.
Lusty Juventus, 369, 382.
Lydgate, 327, 328, 336, 379.
Macropedius, 380.
Magnificence, 355, 341, 346, 360, 362, 383.
Mankind, 358, 387, 391–92.
Marguet Convertie, 345.
Marriage of Wit and Science, The, 379.
Martianus Capella, 380.
Mary Magdalene, 331, 384.
Medwell, 332, 379.
Menaechmi, 383.
Merry Knack to Know a Knave, A, 399.
Misogonus, 382–83.
Moral plays, analogues in medieval sermons, 304–12; sources: the *Psychomachia*, 293, 320–33, the legend of Antichrist, 346–51, the Dance of Death, 317, 341, 351–54, the allegory of Psalms, 85. 10, 318, 354–58; as a means of theological instruction, 333–41; as connected with the Reformation, 359–75;

and with the Renaissance, 375–86; and with the spirit of comedy, 387–90, *et passim*; their presentation, 389–95; restrained by law, 364, 373–75; kept alive by new needs, 359–86, their disintegration, 386–403.
Moralité des Enfans de Maintenant, 382.
Morals of the Book of Job, 330.
More, 366.
Mystère de la Passion, 356.
Narrenschiff, 360.
Nature, 332, 378, 379, 383, 393, 395.
Nature of the Four Elements, The, 376–78, 381, 383.
New Custom, 369, 393.
Nice Wanton, The, 381.
Occleve, 360.
Origen, 349.
Pageants, political and religious, 364.
Palsgrave, 381.
Pammachius, 366, 367, 374.
Parabell, 380.
Pastor of Hermas, 309, 329.
Pastoral Care, The, 295, 296, 328.
Pater Noster: see Lord's Prayer.
Paul, Saint, 320–21, 322, 348.
Peter of Blois, 310, 327.
Pierre de Limoges, 300.
Plautus, 383, 384, 399.
Play of the Sacrament, The, 336.
Pore Help, A, 369.
Presentation of plays, 389–95.
Pride of Live, The, 353, 358, 389, 390, 392–93, 395.
Prodigal Son, the, plays on, 380–81, 386.
Prudentius, 322.
Psalms 85. 10, in allegory, 354–58.
Psychomachia, its origin, 320–22; in literature, 326–32; and in art, 328; the main source of the moral play, 293. Also, 311, 320–33, 334, 341, 343, 346.
Raoul de Houdan, 327.
Realism, 387–89, *et passim*.
Rebelles, 380–82.
Redford, 379, 384.
Reformation, plays concerned with, 359–75.
Regement of Prynces, 360.
Renaissance, plays concerned with, 375–86.
Reson and Sensualyte, 379.
Respublica, 359, 370, 393, 395.
Rich, Archbishop, 335.
Roman de la Rose, 332.
Roo, 364, 373.
Rutebeuf, 327.
Saint John the Evangelist, 340–41, 389.
Salutation and Conception, The, 357.
School-plays, 376–86.
Secreta Secretorum, 360.
Sermon, the, in early Christian worship, 293–94; its decline, 294–95; its revival, 295–312; methods of adaptation, 296–312; dramatic character of, 303–12; use of allegory in, 308–12.
Sermones Vulgares, or, *Sermones ad Status*, 298, 299.
Sermonnaire: see *Homilaria*.
Sir Thomas More, 401.
Skelton, 360, 362, 383.
Somebody, Avarice, and Minister, 372.
Somme des Vices et des Vertues, 335.
Songe de Paradis, 327.
Speculum Ecclesiae, 296, 297, 298, 305, 334.
Spira, 368.
Strabo, 334.
Studentes, 381, 383.
Stymmelius, 381.
Summa de Arte Praedicatoria, 297.
Tertullian, 309, 321.
Thersites, 398.
Three Ladies of London, The, 372, 384.
Three Laws, The, 361, 367, 369.
Three Lords and the Three Ladies of London, The, 372.

Tom Tyler, 384, 388.
Tornoiemenz Antecrit, Li, 326.
Trial of Treasure, The, 383, 397.
Turner, 366.
Tyde Taryeth No Man, The, 372.
Tyndale, 366.
Vice, the, on the stage, 395–97, 401–402.
Vincent of Beauvais, 377.
Virtutum Vitiorumque Exempla, 302.
Voie de Paradis, 359.
Wager, 388.
Waldis, 380.
Wapull, 372.
Wealth and Health, 394.
Wever, 369.
Wiclif, 334.
Wilson, 346, 400–401.
Wisdom Who Is Christ, 338–40, 341, 394, 396.
Wit and Science, 379, 381, 383, 384.
Woodes, 367.
World and the Child, The, 336, 337, 393.
Wylley, 369.
York, Plays at, 334–35, 382, 391.
Youth, 388.

OF SCIENCES

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 1-57 SEPTEMBER, 1908

On the Theory of Double Products and Strains in Hyperspace

BY

EDWIN BIDWELL WILSON

PUBLISHED UNDER THE AUSPICES OF

YALE UNIVERSITY

NEW HAVEN, CONNECTICUT

1908

WEIMAR: PRINTED BY R. WAGNER SOHN

I.—On the theory of double products and strains in hyperspace.

By Edwin Bidwell Wilson.

Part I.—On a multiple algebra as set forth by Gibbs.

Introduction.

1. *History and apologies.*—During the academic year 1899–1900, I followed a course of lectures on vector analysis by the late professor J. Willard Gibbs. These lectures, with some alterations as to additions and retrenchments, I published with his permission in the year 1901.[1] Previously to this, during the academic year 1900–1901, I had the opportunity of following a short course of twenty-five or thirty lectures on multiple algebra under the same master. These lectures have never been published, and very likely never can be. My own notes were very meager and most of them have unfortunately been lost. There remains, however, a set of notes taken by the late professor G. P. Starkweather of Yale University. These notes were of a similar course given during the academic year 1895–1896; and as nearly as my memory and the fragments of my own notes will serve me, it appears that Gibbs had not materially changed his course during the intervening five years. It is therefore from Starkweather's notes that the following articles on multiple algebra are drawn, with the practical certainty that the presentation is essentially that followed by Gibbs in his later years.

Gibbs's course on multiple algebra, following immediately upon his lectures on vector analysis, began with a discussion of quaternions defined as the sum of the vector product and the negative of the scalar product of two vectors, and then turned to the geometric

[1] Vector Analysis, a textbook for the use of students of mathematics and physics, founded upon the lectures of J. Willard Gibbs. Yale Bicentennial Publications, Charles Scribner's Sons, New York, and Edwin Arnold, London. xviii + 436 pp. A second edition, merely corrected, has recently appeared. References in the text to Vector Analysis are to either edition. Gibbs's original pamphlet on vector analysis, printed privately in 1881–1884 but never published, may now be found reprinted in the collection of The Scientific Papers of J. Willard Gibbs, volume 2, pp. 17–90.

algebras, that is, the point-, line-, and plane-analyses of Grassmann. These subjects occupied approximately half the time of the course. During the remaining half, he took up the theory of dyadics, which is in immediate and intimate connection with the theory of matrices, and concluded with C. S. Peirce's thorem that any linear associative algebra may be put in quadrate, that is, in matricular form. This brief series of lectures by no means contained all of Gibbs's ideas and developments in multiple algebra. Indeed he had published at a much earlier date some reflections and theories on the subject[1] which found no place in his course. An examination of the notes which he left at his death shows, however, that he followed his usual custom of not committing his results to paper except in so far as they were immediately needed for the lectures in his course.

The reason for my being so bold at this time as to publish some of the most essential extracts from Gibbs's lectures on multiple algebra is partly because they may be of interest to mathematicians who may be concerned with the theory of matrices or with multiple algebra, and partly because I desire to make use of the abbreviations which his notation and methods afford in discussing some geometric problems in connection with the theory of strains. If at any time in developing the multiple algebra I take the liberty of adding to what I find in Starkweather's notes or in my own, or if I depart from the methods of Gibbs, I shall try to make the fact evident—not for the purpose of claiming any originality of my own, but that the reader may have as definite as possible an idea of what Gibbs did in his course on multiple algebra, in so far as I find it necessary or advisable to print it at this time.

2. *Preliminary notions and notations.*—Let the primary elements of the algebra be denoted by Greek small letters, $\alpha, \beta, \gamma, \ldots$. If the algebra is n-dimensional, any $n+1$ of the elements will be connected by a linear relation,

$$\Sigma\, a\alpha + b\beta + c\gamma + \ldots \text{ to } n+1 \text{ terms} = 0,$$

with scalar coefficients $a, b, c, \ldots$ not all of which are zero; and any element of the system may be expressed linearly with scalar coefficients in terms of any given n linearly independent elements, as

$$(1) \qquad \varrho = \Sigma\, a\alpha + b\beta + c\gamma + \ldots \text{ to } n \text{ terms}.$$

[1] On Multiple Algebra, an address before the section of mathematics and physics of the American Association for the Advancement of Science, by the Vice-President. Proceedings of the American Association for the Advancement of Science, volume 35, pp. 37–66. This address is reprinted in The Scientific Papers, volume 2, pp. 91–117.

Moreover, the system will be supposed, as usual, to contain all the elements which may be linearly derived from any given elements; and it may be assumed that the coefficients in this derivation are any real or complex scalars. It will not be necessary to go into further details as regards these matters which are the same in all linear associative or Grassmannian algebras. So much in regard to addition, subtraction, and linear dependence or independence.

The primary elements $\alpha, \beta, \gamma, \ldots$ may be interpreted either as vectors issuing from a fixed point in Euclidean space of n dimensions or as points lying in a Euclidean space (supposed flat, of course) of n—1 dimensions. It is the former interpretation which will be most used in what follows. It should be noted however, that the algebraic system is independent of any geometric interpretation. If proofs are given by means of either of the said interpretations, it is merely because the geometric language facilitates expression. As a matter of fact in a Grassmannian algebra where the combinatory products lead to elements of different types from the elements which constitute the factors, the geometric language and conception are far more fruitful and convenient than in those algebras in which the product is always of the same type as the factors; and hence it will be used constantly in what follows.

Two primary elements may be multiplied according to the combinatory law

$$\alpha \times \beta = -\beta \times \alpha \tag{2}$$

to form a product which is an element of another type and may be called a secondary element or element of the second class. The use of the cross $\times$ for combinatory multiplication it in accord with Gibbs's usage in his address on multiple algebra. In like manner k elements, $k \leqq n$, may be combined to form an element of the kth class. Such multiplication is called progressive; it is associative and it is distributive relative to expressions such as (1). If an element of class k be multiplied into an element of class l, $k + l \leqq n$, the multiplication remains progressive; if $k + l$ n, the product is of class n and is a scalar. The properties of progressive multiplication as contained in (2) and in the associative and distributive laws are simple and are treated in a variety of places.[1] If the sum of the classes, $k + l$, of two elements is greater than n, the rules of progressive multiplication give a zero value for the product and it

[1] For instance, in either of Grassmann's Ausdehnungslehren, 1844 and 1862, or in Whitehead's Universal Algebra, volume 1, Cambridge University Press.

becomes necessary to redefine the method of evaluating the product. Thus arises the theory of regressive multiplication in which the class of the product is $k + l - n$ instead of $k + l$. This product is also treated in detail in the references just cited.

It should be noted, however, that the theory of regressive multiplication, which is usually based upon the theory of supplements in the Grassmannian sense, was treated in an entirely different manner by Gibbs. His point of view and method of procedure were outlined in his address on multiple algebra already cited: but as that presentation is extremely brief, it may be well to recapitulate his method in some detail. Let $\alpha, \beta, \gamma, \ldots$ be any number of elements of the first class. Consider the product of two factors (the cross introduced in (2) may be omitted for brevity in writing)

$$(\alpha\,\beta\,\gamma\,\delta\ldots)\ (\ldots\lambda\,\mu\,\nu\,\pi)$$

each of which contains not more than n elements, say k and l respectively, but which together contain more than n elements. The product of two such factors is called regressive when computed by either of the following rules:

1°. From the second factor $(\ldots\lambda\,\mu\,\nu\,\pi)$ take enough, that is, $n - k$, of the remoter (last) elements to form a total of n with all the elements of the first factor $(\alpha\,\beta\,\gamma\,\delta\ldots)$, thus obtaining a scalar (a product of the nth class) to serve as coefficient to the remaining elements of the second factor. Do this for every permutation of the l elements in the second factor $(\ldots\lambda\,\mu\,\nu\,\pi)$ which may be necessary to bring every combination (not permutation) of $n - k$ of them once and only once to the end of the factor, and add the results thus obtained with the positive or negative sign according as the number of simple transpositions of the l elements in any permutation is even or odd.

2°. From the first factor take enough, that is, $n - l$, of the remoter (first) elements to form a total of n with all the elements of the second factor, thus obtaining a scalar to serve as coefficient to the remaining elements of the first factor. Do this ... and so on, as before.

Thus if $n = 4$, the following expansions of regressive products are in accordance with the rules just stated.

$$\alpha\,(\beta\,\gamma\,\delta\,\varepsilon) = (\alpha\,\gamma\,\delta\,\varepsilon)\,\beta - (\alpha\,\delta\,\varepsilon\,\beta)\,\gamma + (\alpha\,\varepsilon\,\beta\,\gamma)\,\delta - (\alpha\,\beta\,\gamma\,\delta)\,\varepsilon,$$

$$(\alpha\,\beta\,\gamma)\,(\delta\,\varepsilon) = (\alpha\,\beta\,\gamma\,\varepsilon)\,\delta - (\alpha\,\beta\,\gamma\,\delta)\,\varepsilon = (\alpha\,\beta\,\delta\,\varepsilon)\,\gamma + (\beta\,\gamma\,\delta\,\varepsilon)\,\alpha + (\gamma\,\alpha\,\delta\,\varepsilon)\,\beta,$$

$$(\alpha\,\beta\,\gamma)\,(\delta\,\varepsilon\,\zeta) = (\alpha\,\beta\,\gamma\,\zeta)\,\delta\,\varepsilon + (\alpha\,\beta\,\gamma\,\varepsilon)\,\zeta\,\delta + (\alpha\,\beta\,\gamma\,\delta)\,\varepsilon\,\zeta = (\alpha\,\delta\,\varepsilon\,\zeta)\,\beta\,\gamma + (\beta\,\delta\,\varepsilon\,\zeta)\,\gamma\,\alpha + (\gamma\,\delta\,\varepsilon\,\zeta)\,\alpha\,\beta.$$

It may be remarked that in the first line, the product on the left of the sign of equality is already expanded as far as possible by the second of the rules. Furthermore, if n had been 5, the last product would have been

$$(\alpha\,\beta\,\gamma)\,(\delta\,\varepsilon\,\zeta) = (\alpha\,\beta\,\gamma\,\varepsilon\,\zeta)\,\delta + (\alpha\,\beta\,\gamma\,\delta\,\varepsilon)\,\zeta + (\alpha\,\beta\,\gamma\,\zeta\,\delta)\,\varepsilon = (\alpha\,\beta\,\delta\,\varepsilon\,\zeta)\,\gamma + (\beta\,\gamma\,\delta\,\varepsilon\,\zeta)\,\alpha + (\gamma\,\alpha\,\delta\,\varepsilon\,\zeta)\,\beta.$$

It is hardly necessary to note that the signs in the expansions may all be taken positive by properly arranging the permutations on the letters.

Obviously, if the numbers of the elements in the factors are k and l, the product belongs to class $k + l - n$. It is of fundamental importance to observe that the way in which the regressive product is defined by reference to the progressive product of n elements, is sufficient to insure the distributivity of the regressive product relative to sums.

To justify the double definition, it is necessary to show that the two rules lead to the same result. For this, it is convenient to consider all the primary elements as expressed linearly in terms of n independent primary unit elements, all elements of higher classes as expressed in terms of the unit elements of those classes. Then, inasmuch as the distributive law applies to the regressive product and the product of two sums of terms may be resolved into the sum of the products of each pair of terms, of which one is selected from the first factor and one from the second, it is sufficent to prove the equivalence of the two rules for factors made up of certain of the units. As the factors contain respectively k and l units, and as there are only n units in all, there must be $k + l - n$ units common to the two factors; it being understood that if any unit is repeated in both factors, it may be repeated in the list of common units as many times as it occurs in the factor in which it occurs least frequently, unless so great a repetition is not required to make up a total of $k + l - n$ common units, after all those which are common to both factors, but are not repeated in more than one of the factors have been counted. Let the product of the $k + l - n$ units common to the two factors be M, and let the two factors be written as AM and MB. Consider the product $AM \times MB$, where it is clear that A contains $n - l$ and B contains $n - k$ units. According to the first rule it is necessary to select $n - k$ elements from MB to form with the k elements in AM a scalar coefficient for the remaining elements of MB. If any of these $n - k$ are taken from M, the resulting scalar will surely have a repeated unit and will vanish. Hence all $n - k$ should be taken from B, and according to the first rule the product is

$$AM \times MB = (AMB)\, M \tag{3}$$

The same result is obtained by a similar application of the second rule.

A further word on the geometrical interpretation will considerably facilitate the expression of some of the following remarks. If the primary elements be interpreted as vectors issuing from a fixed point in Euclidean space of n dimensions, the elements of the second class will be conceived as plane areas and in particular the product of two vectors will be the parallelogram included by them, the elements of the third class will be three-dimensional volumes, and so on until the scalars which are elements of the nth class will be n-dimensional volumes, and in particular the product of n vectors will be the n-dimensional parallelepiped constructed upon them. It appears therefore that the necessary and sufficient condition that k vectors $k \leqq n$, be linearly dependent is that their (progressive) product be zero. The regressive product is the product of two factors, which, regarded as spaces, have a total dimensionality greater

than n. Formula (3) shows that in case the factors are made up of units, the regressive product is the space common to the two spaces of the factors, that is, it is the intersection of the factors, taken, of course, with a certain magnitude. An examination of the rules for expanding the regressive product, especially as illustrated by the examples there given, shows at once that the result is true in general, and that the regressive product of two spaces is always the intersection of the spaces, taken with a proper numerical value. It should be noted that if the spaces of two factors in a regressive product do not exhaust the dimensionality of all space, that is, if the spaces of both factors lie in a subspace of the n-dimensional space, then the scalar coefficients which occur in the expansion of the product will be products of n vectors lying in that subspace and will therefore all vanish. That is to say, if the factors lie in a subspace, the regressive product must be zero.

This fact may serve as foundation for the proof of the associative law for the multiplication of three factors, which may be denoted by X, Y, Z. If X and Y lie in a subspace of the n-dimensional space, the regressive product XY is zero and hence XY times Z is necessarily zero. But if X and Y lie in a subspace, so must X and the product YZ, which is the space common to Y and Z. Hence X times YZ is also zero; and the associative law holds in this case. To prove the law in general it is sufficient, owing to the applicability of the distributive law, to prove it for the case that X, Y, Z are products of the units. Furthermore, it may be assumed that X and Y, and also Y and Z, exhaust the n dimensions of space. Let M represent the product of the units common to X, Y, Z; and let A be the product of the units other than those in M which are common to Y and Z; and similarly B and C for the pairs Z, X and X, Y. Then as X and Y and also Y and Z must exhaust all n-dimensions of space, it is obvious that every unit which occurs in X must occur in Y or Z, and similarly for Y and Z. Hence the factors may be written as

$$X = B\,M\,C \qquad Y = C\,M\,A \qquad Z = A\,M\,B$$

and the two groupings of the factors give

$$\begin{aligned}[X\,Y]\,Z &= [(B\,M\,C)\,(C\,M\,A)]\;(A\,M\,B) = [(B\,M\,C\,A)\,C\,M]\;(A\,M\,B)\\ &= (B\,M\,C\,A)\,(C\,A\,M\,B)\,M,\\ X\,[Y\,Z] &= (B\,M\,C)\;[(C\,M\,A)\,(A\,M\,B)] = (B\,M\,C)\;[(C\,A\,M\,B)\,M\,A]\\ &= (B\,M\,C\,A)\,(C\,A\,M\,B)\,M,\end{aligned}$$

which are equal; and the associative law is proved. Care should, however, be exercised against applying the law to cases to which it cannot apply, such as

$$n = 5, \quad [(\alpha\,\beta\,\gamma)\,\delta\,\varepsilon]\,(\delta\,\varepsilon\,\alpha) = 1\;(\delta\,\varepsilon\,\alpha), \quad (\alpha\,\beta\,\gamma)\,[(\delta\,\varepsilon)\,(\delta\,\varepsilon\,\alpha)] = 0.$$

Here the products are not regressive, but progressive.

In addition to the combinatorial product $\alpha \times \beta$ of two elements there is the dyadic product $\alpha\beta$. This corresponds to the simplest type of Grassmann's Lückenausdrücke. It is, according to Gibbs's

definition, a mere formal juxtaposition of two letters subject to the distributive law; that is,

$$\alpha(\beta+\gamma)=\alpha\beta+\alpha\gamma \quad \text{and} \quad (\alpha+\beta)\gamma=\alpha\gamma+\beta\gamma.$$

Hence if α and β are each expressed in terms of n given independent elements (which need not be the same set of n for both vectors), the product $\alpha\beta$ may be expanded into a block of n^2 terms or dyads. It is through this fact that connection is made with the theory of matrices. There is no necessity that the two elements in a dyadic product should belong to the same class, whether primary or otherwise. If Γ and Δ belong respectively to the kth and lth classes, the dyad $\Gamma\Delta$ may be defined in a manner similar to $\alpha\beta$ as a formal juxtaposition of two elements subject to the distributive law. As the kth and lth classes contain respectively

$$\frac{n(n-1)\dots(n-k+1)}{k!} \quad \text{and} \quad \frac{n(n-1)\dots(n-l+1)}{l!}$$

linearly independent elements, the dyad $\Gamma\Delta$ may be expanded into a block of $n\dots(n-k+1)\,.\,n\dots(n-l+1)\,/\,k!\,l!$ terms. These terms will not form a square matrix unless $k=l$ or $k+l=n$; in other cases the matrix will be rectangular.

Gibbs applied also the name indeterminate product to the combination $\alpha\beta$ or $\Gamma\Delta$, and he was very particular to state that he considered it the most general and most essential product with which multiple algebra has to deal.[1] Other products may be regarded as functions of the dyadic product. This product determines its constituent elements α and β, or Γ and Δ, except that a scalar factor may be transferred from one to the other. The proof of this is not essentially different from that given for the simple case of vectors in the Vector Analysis, page 272. In what follows, the only dyadic products which will be considered are those in which the sum of the class-numbers k and l is equal to n. In this case the combinatorial product of two like dyads $\Gamma\Delta$ and $\Gamma'\Delta'$ is defined by the simple equation

$$(4) \qquad (\Gamma\Delta)\times(\Gamma'\Delta')=\Gamma(\Delta\times\Gamma')\,\Delta'=(\Delta\times\Gamma')\,\Gamma\Delta'$$

where $\Delta\times\Gamma'$ is necessarily a scalar. The product therefore reduces to a similar dyad $\Gamma\Delta'$ modified by a scalar factor. In like manner the product of a dyad into an element of the same class as the first member of the dyad is defined by the equation

[1] See his address On Multiple Algebra, pp. 23–25; The Scientific Papers, volume 2, pp. 109–111: also Vector Analysis, article 102, pp. 271–275. The question is also treated in my communication On Products in Additive Fields: Verhandlungen des dritten internationalen Mathematiker-Kongresses. Teubner, 1905, pp. 202–215.

$$(4') \qquad (\Gamma\Delta)\times\Gamma' = \Gamma(\Delta\times\Gamma') = (\Delta\times\Gamma')\Gamma$$

where $\Delta\times\Gamma'$ is a scalar, and the result is therefore an element of the same class as that which was multiplied by the dyad.

3. *Reciprocal sets of elements.*—The theory of reciprocal sets is fundamental to the entire treatment of multiple algebra as here given. To a large extent it obviates the necessity of discussing the theory of supplements in the Grassmannian sense. In fact, by his definition and treatment of regressive multiplication and by his theory of reciprocal sets, Gibbs entirely avoided the supplements in his course. Before proceeding, however, to the reciprocal sets, it will be well to introduce once for all the change of notation already adopted in the discussion of regressive multiplication. The sign of the combinatorial product, the cross $\times$, occurs so frequently as to render the formulas too bulky. I shall therefore write

$$\Gamma\Delta \text{ instead of } \Gamma\times\Delta$$

for the combinatorial product. This necessitates a different notation for the dyadic product, and I shall write for this product

$$\Gamma|\Delta \text{ instead of } \Gamma\Delta,$$

where it should be noted that the vertical bar has no relation to the Ergänzung of Grassmann. This is in entire accord with Gibbs's procedure in his lectures; the change is made purely for convenience. The reason that this notation was not adopted from the start was to emphasize the fact that the dyadic product was fundamental and the combinatory product merely a function of it.

Let there be given n independent primary vectors or elements

$$\alpha_1,\ \alpha_2, \ldots,\ \alpha_n, \qquad \alpha_1\ \alpha_2 \ldots \alpha_n \neq 0.$$

Form the n expressions

$$(5) \qquad \alpha'_i = \frac{\alpha_{i+1}\ \alpha_{i+2} \ldots \alpha_n\ \alpha_1\ \alpha_2 \ldots \alpha_{i-1}}{\alpha_{i+1}\ \alpha_{i+2} \ldots \alpha_n\ \alpha_1\ \alpha_2 \ldots \alpha_{i-1}\ \alpha_i}, \quad i = 1,\ 2,\ \ldots,\ n.$$

The n quantities $\alpha'_1, \alpha'_2, \ldots \alpha'_n$ thus obtained are elements of the $(n-1)$st class. Taken as a set, they are called the reciprocal set to the n elements $\alpha_1, \alpha_2, \ldots, \alpha_n$. For brevity α'_i is sometimes called the reciprocal of α_i. From the definition (5) of the reciprocal set it appears that the elements and their reciprocals satisfy the equations

$$(6) \qquad \alpha'_i\ \alpha_i = 1, \qquad \alpha'_i\ \alpha_j = 0, \qquad i \neq j.$$

By the laws of regressive multiplication it follows that the $n(n-1)/2$ elements $\alpha'_i\ \alpha'_j$ of the $(n-2)$nd class and the equal number of elements $\alpha_i\ \alpha_j$ of the second class satisfy the equations

$$(6') \qquad \alpha'_i\ \alpha'_j\ \alpha_i\ \alpha_j = 1, \qquad \alpha'_i\ \alpha'_j\ \alpha_k\ \alpha_l = 0, \quad k \text{ and } l \text{ not both equal to } i \text{ and } j.$$

Similar equations are satisfied by the elements $\alpha'_i\ \alpha'_j\ \alpha'_k$ of the

$(n-3)$rd class and the elements $\alpha_i\ \alpha_j\ \alpha_k$ of the third class. And so on, until finally

$$(6'') \qquad (\alpha'_1\ \alpha'_2 \dots \alpha'_n)\ (\alpha_1\ \alpha_2 \dots \alpha_n) = 1.^1$$

These equations are entirely analogous to those obtained in (6) for the reciprocals themselves. The extension of the idea of reciprocal sets to other than the primary elements is therefore suggested; and if equations analogous to (5) be formed for such elements, the theorem may be stated that: The reciprocals of the combinatory products of the set of n primary elements are the products of the reciprocals of those elements. Or it may be preferable to regard this statement taken with the equations (6') and analogous equations as the definition of the reciprocals without appealing to equations analogous to (5). The sum of the class-number of any one of a set of elements and of the class-number of any one of the reciprocal set is n.

Equation (6'') shows that $(\alpha'_1\ \alpha'_2 \dots \alpha'_n) \neq 0$, and hence the reciprocals $\alpha'_1, \alpha'_2, \dots, \alpha'_n$ are themselves independent. From this

---

[1] The proofs are very simple. For instance to show that $(\alpha'\ \beta'\ \gamma')\ (\alpha\ \beta\ \gamma) = 1$, it is merely necessary to analyze as follows.

$$(\alpha'\ \beta'\ \gamma')\ (\alpha\ \beta\ \gamma) = \alpha'\ \beta'\ [\gamma'\ (\alpha\ \beta\ \gamma)] = \alpha'\ \beta'\ [(\gamma'\ \gamma)\ (\alpha\ \beta) + (\gamma'\ \alpha)\ (\beta\ \gamma) + (\gamma'\ \beta)\ (\gamma\ \alpha)] = (\alpha'\ \beta')\ (\alpha\ \beta);$$

for $\gamma'\ \gamma$ is 1 and $\gamma'\ \alpha$ and $\gamma'\ \beta$ are both 0. A repetition of the process shows the desired relation. In a similar manner the other relations may be proved. All the relations are, however, but special cases of an important formula. Let $\bar{\alpha}, \bar{\beta}, \bar{\gamma}, \dots$ be elements of class $n-1$, in number less than or equal to n, and let $\alpha, \beta, \gamma, \dots$ be an equal number of elements of the first class. The product $(\alpha\ \beta\ \gamma \dots)\ (\bar{\alpha}\ \bar{\beta}\ \bar{\gamma} \dots)$ is evidently a scalar and is given by the formula

$$(\alpha\ \beta\ \gamma \dots)\ (\bar{\alpha}\ \bar{\beta}\ \bar{\gamma} \dots) = \begin{vmatrix} \alpha\,\bar{\alpha} & \alpha\,\bar{\beta} & \alpha\,\bar{\gamma} \dots \\ \beta\,\bar{\alpha} & \beta\,\bar{\beta} & \beta\,\bar{\gamma} \dots \\ \gamma\,\bar{\alpha} & \gamma\,\bar{\beta} & \gamma\,\bar{\gamma} \dots \\ \dots & \dots & \dots \dots \end{vmatrix}.$$

The proof is given by applying the laws of regressive multiplication. Consider $(\alpha\ \beta\ \gamma \dots)$ as a single element and apply the associative law and the rule for expanding:

$$(\alpha\ \beta\ \gamma \dots)\ (\bar{\alpha}\ \bar{\beta}\ \bar{\gamma} \dots) = (\alpha\ \beta\ \gamma \dots \bar{\alpha})\ (\bar{\beta}\ \bar{\gamma} \dots) = [(\alpha\,\bar{\alpha})(\beta\ \gamma \dots) - (\beta\,\bar{\alpha})\ (\alpha\ \gamma \dots) + (\gamma\,\bar{\alpha})\ (\alpha\ \beta \dots) - \dots]\ (\bar{\beta}\ \bar{\gamma} \dots)$$

By a repetition of this process on each of the terms of the form

$$(\beta\ \gamma \dots)\ (\bar{\beta}\ \bar{\gamma} \dots), \qquad (\alpha\ \gamma \dots)\ (\bar{\beta}\ \bar{\gamma} \dots), \qquad (\alpha\ \beta \dots)\ (\bar{\beta}\ \bar{\gamma} \dots).$$

a further reduction is accomplished, and so on. The final result will clearly be equal to the determinant—in fact the step already taken appears as the expansion of the determinant according to elements of the first column. If this formula be used, the relations between the reciprocals are immediate.

follows the theorem: If any set of n quantities of the $(n-1)$st class, $\bar{\beta}_1, \bar{\beta}_2, \ldots, \bar{\beta}_n$, satisfy the equations (6), the elements $\bar{\beta}_i$ and α'_i are identical. For the $\bar{\beta}$'s may be expressed linearly in terms of the α's as

$$\bar{\beta}_i = a_{1i}\ \alpha'_1 + a_{2i}\ \alpha'_2 + \ldots + a_{ni}\ \alpha'_n$$

and then equations (6) give the equations $a_{ii} = 1$, $a_{ji} = 0$. Thus the uniqueness of the reciprocal set is established. Furthermore equations (6), (6′), ... may be written in the form

$$\begin{aligned} &\alpha_i\ \alpha'_i = \pm 1 && \alpha_j\ \alpha'_i = 0 \\ (6''')\qquad &\alpha_i\ \alpha_j\ \alpha'_i\ \alpha'_j = +1 && \alpha_k\ \alpha_l\ \alpha'_i\ \alpha'_j = 0, \\ &\ldots\ldots\ldots && \ldots\ldots\ldots, \end{aligned}$$

where the negative signs hold when and only when n is even, and then only in every alternate equation. From the uniqueness of sets of reciprocals the theorem may therefore be stated that: The reciprocals of a given set of elements are equal to the given set except when their class-number is odd and n is even, in which case they are the negative of the given set.

One of the prime uses of the reciprocals is to express the idemfactors. To avoid the introduction of subscripts, let $\alpha, \beta, \gamma, \ldots$ be a set of n independent primary elements and $\alpha', \beta', \gamma', \ldots$ their reciprocals. The dyadic expression

$$(7)\qquad I = \alpha\,|\,\alpha' + \beta\,|\,\beta' + \gamma\,|\,\gamma' + \ldots, \qquad n \text{ terms},$$

is called an idemfactor for primary elements. It has the property that when multiplied combinatorially, see (4′), into a primary element, it reproduces that element: that is,

$$I\,\varrho = (\alpha\,|\,\alpha' + \beta\,|\,\beta' + \gamma\,|\,\gamma' + \ldots)\ \varrho = \alpha\,(\alpha'\,\beta) + \beta\,(\beta'\,\varrho) + \gamma\,(\gamma'\,\varrho) + \ldots = \varrho.$$

This may be seen by considering ϱ as expressed in terms of $\alpha, \beta, \gamma, \ldots$. In like manner the dyadic expression

$$(7')\qquad I_2 = \Sigma\ \alpha\,\beta\,|\,\alpha'\,\beta', \qquad n\,(n-1)\,/\,2 \text{ terms},$$

is an idemfactor for elements of the second class, that is, $I_2\,\varrho\,\sigma = \varrho\,\sigma$. And

$$(7'')\qquad I_3 = \Sigma\ \alpha\,\beta\,\gamma\,|\,\alpha'\,\beta'\,\gamma' \qquad n\,(n-1)\,(n-2)\,/\,6 \text{ terms},$$

is an idemfactor for elements of the third class. And so on.

Elementary Properties of Dyadics.

4. *Various representations of dyadics.*—For the present purposes, the primary dyad will be defined as one whose first factor is a primary element and whose second factor is an element of the $(n-1)$st class. For brevity, these factors will be designated respectively as the antecendent and the consequent. To bring out

more clearly the different classes of the antecedent and the consequent, the former will be denoted by a Greek small letter and the latter by a Greek small letter carrying a dash—thus $\alpha \mid \bar{\lambda}$. Dyads of the form $\alpha\beta \mid \bar{\lambda}\bar{\mu}$ may be called secondary, and so on. The notation of the reciprocal set to n elements $\alpha, \beta, \gamma, \ldots$ has been $\alpha', \beta', \gamma', \ldots$; and this will be adhered to. The dashes will not be introduced to call additional attention to the class of the reciprocals. The set of reciprocals of n independent elements of the $(n-1)$st class $\bar{\alpha}, \bar{\beta}, \bar{\gamma}, \ldots$ will be represented by $\bar{\alpha}', \bar{\beta}', \bar{\gamma}', \ldots$ and will be of the first class.

The sum of any number of primary dyads

$$\Phi = \alpha_0 \mid \bar{\alpha}_0 + \beta_0 \mid \bar{\beta}_0 + \gamma_0 \mid \bar{\gamma}_0 + \cdots \tag{8}$$

is called a dyadic polynomial or simply a dyadic. As was stated in article 2, each of the dyads may be expanded as a block of n^2 terms by expressing the antecedents and the consequents in terms of a set of independent elements $\alpha, \beta, \gamma, \ldots, \nu$ and $\bar{\alpha}, \bar{\beta}, \bar{\gamma}, \ldots, \bar{\nu}$. If this be done the dyadic Φ takes the form

$$\begin{aligned} \Phi = {} & c_{aa}\, \alpha \mid \bar{\alpha} + c_{ab}\, \alpha \mid \bar{\beta} + \ldots + c_{an}\, \alpha \mid \bar{\nu} \\ & + c_{ba}\, \beta \mid \bar{\alpha} \;.\;.\;.\;.\;.\;. + c_{bn}\, \beta \mid \bar{\nu} \\ & + .\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;. \\ & + c_{na}\, \nu \mid \bar{\alpha} + \;.\;.\;.\;.\;. + c_{nn}\, \nu \mid \bar{\nu}. \end{aligned} \tag{9}$$

If these terms be added according to rows or according to columns, Φ reduces to a sum of n terms:

$$\begin{aligned} \Phi &= \alpha \mid \bar{\alpha}_1 + \beta \mid \bar{\beta}_1 + \ldots + \nu \mid \bar{\nu}_1, \\ \Phi &= \alpha_1 \mid \bar{\alpha} + \beta_1 \mid \bar{\beta} + \ldots + \nu_1 \mid \bar{\nu}. \end{aligned} \tag{9'}$$

In this reduction to a sum of n terms, either the antecedents or the consequents may be chosen arbitrarily, but not both. The most useful reduction to the form (9) is when the antecedents and consequents are reciprocal sets.

Two dyadics Φ and Ψ may be said to be equal if the n^2 coefficients c_{ij} are equal when the dyadics are both reduced to the form (9) in terms of the same antecedents and the same consequents. Another definition, which is preferable and obviously reducible to this, is contained in any one of the three statements: Two dyadics Φ and Ψ are equal when and only when

$\Phi\varrho = \Psi\varrho$ for all values of ϱ

or $\bar{\sigma}\Psi = \bar{\sigma}\Psi$ for all values of $\bar{\sigma}$

or $\bar{\sigma}\Phi\varrho = \bar{\sigma}\Psi\varrho$ for all values of ϱ and $\bar{\sigma}$.

To insure the equality, it is not necessary to verify these equations for all values of ϱ or of $\bar{\sigma}$ or of ϱ and $\bar{\sigma}$. If the equations hold respectively for n independent values of the elements in question, they will hold for all values. In fact, by the aid of reciprocals the

dyadic which converts n given independent elements $\alpha, \beta, \ldots, \nu$ into n elements $\alpha_1, \beta_1, \ldots, \nu_1$, not necessarily independent, may be written down as

(10) $$\Phi = \alpha_1|\alpha' + \beta_1|\beta' \ldots + \nu_1|\nu', \quad \Phi\,\alpha = \alpha_1, \text{ etc.}$$

If the antecedents of this dyadic are not linearly independent, the expression may be reduced to a sum of l dyads where $l < n$. In general if the antecedents or consequents or both, which occur in the reduction of a dyadic to a sum of n terms, be not independent, the dyadic may be reduced to a sum of dyads less than n in number. If l be the least number of dyads which may be obtained in the reduction

(11) $$\Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \ldots + \lambda|\bar{\lambda} \qquad (l \text{ terms}),$$

where the antecendents and consequents are now linearly independent, the dyadic is said to have nullity of degree $n—l$. If the elements be interpreted as vectors issuing from an assumed origin in space of n dimensions, the nullity may be stated geometrically by saying that by the operation of the dyadic the n-dimensional space has been converted into a flat subspace of l dimensions passing through the assumed origin.

In like manner the dyadic which, used as a postfactor, converts the n independent elements $\bar{\alpha}, \bar{\beta}, \ldots, \bar{\nu}$ into $\bar{\alpha}_1, \bar{\beta}_1, \ldots, \bar{\nu}_1$ is

(10′) $$(-1)^{n-1}\,\Phi = \bar{\alpha}'|\bar{\alpha}_1 + \bar{\beta}'|\bar{\beta}_1 + \ldots + \bar{\gamma}'|\bar{\gamma}_1, \quad \bar{\alpha}\,\Phi = \bar{\alpha}_1, \text{ etc.},$$

where the consequents need not be independent. If the dyadic reduces to a sum of l terms, of which the antecedents and consequents are then linearly independent, the degree of nullity is again $n—l$. The application of the dyadic has converted space into a subspace of dimensions l in hyperplanes. This subspace may or may not be identical with that previously obtained by using the dyadic as a prefactor to elements of the first class. In general the two subspaces will not be identical.

5. *Combinatory products of dyadics.*—As the individual dyads satisfy the distributive law, the definition of the product of two dyadics follows immediately from the definition of the product of the dyads as given in article 2. It also follows that the product of dyadics is itself a distributive operation. An examination of the definition shows, however, that the product is not in general commutative but that it is associative, that is,

(12) $$\Phi(\Psi\Omega) = (\Phi\Psi)\Omega = \Phi\Psi\Omega.$$

The associative property is not lost if elements of the proper class are multiplied into the products at either end or at both ends, that is,

(12′) $$(\bar{\sigma}\Phi)(\Psi\varrho) = \bar{\sigma}(\Phi\Psi\varrho) = (\bar{\sigma}\Phi\Psi)\varrho = \bar{\sigma}\Phi\Psi\varrho.$$

If, however, elements were inserted between the dyadics in the product, the associative property would be lost.[1]

If Φ and Ψ are two dyadics which have respectively the nullities $n-k$ and $n-l$, so that

$$\Phi = \alpha_1|\bar{\alpha}_1 + \beta_1|\bar{\beta}_1 + \ldots + \varkappa_1|\bar{\varkappa}_1 \qquad (k \text{ terms})$$

and $$\Psi = \alpha_2|\bar{\alpha}_2 + \beta_2|\bar{\beta}_2 + \ldots + \lambda_2|\bar{\lambda}_2 \qquad (l \text{ terms}),$$

the product $\Phi\Psi$ or the product $\Psi\Phi$ cannot have a nullity less than the greater of the two nullities $n-k$ and $n-l$, nor a nullity greater than the sum, $2n-k-l$, of the nullities. To show that the nullity of $\Phi\Psi$ is at least $n-l$, it is merely necessary to inspect the product

$$\Phi\Psi = (\Phi\alpha_2)|\bar{\alpha}_2 + (\Phi\beta_2)|\bar{\beta}_2 + \ldots + (\Phi\lambda_2)|\bar{\lambda}_2.$$

To show that the nullity is at least as great as $n-k$, consider

$$\Phi\Psi = \alpha_1|(\bar{\alpha}_1\Psi) + \beta_1|(\bar{\beta}_1\Psi) + \ldots + \varkappa_1|(\bar{\varkappa}_1\Psi).$$

To see that the nullity of $\Phi\Psi$ is not greater than $2n-k-l$, consider the antecedents $\Phi\alpha_2, \Phi\beta_2, \ldots, \Phi\lambda_2$ in the first expression of the product. As the nullity of Φ is only $n-k$, not more than $n-k$ dimensions of space are annihilated and hence in the most unfavorable case at least $l-n+k$ of these antecedents must be linearly independent. Hence the nullity of $\Phi\Psi$ is not greater than $n-l+n-k$, and the proposition is proved. It is, of course, obvious that the nullity of the product could not be greater than n. With this understanding the generalisation to a product of any number of factors is immediate. The theorem is due to Sylvester.

If either Φ or Ψ has any degree of nullity, the product cannot equal the idemfactor I, which has no degree of nullity. Dyadics which have no degree of nullity will be called complete. If Φ and Ψ are two complete dyadics which satisfy the relation $\Phi\Psi = I$, they will be called reciprocal dyadics—

(13) $$\Phi\Psi = I = \Psi\Phi, \quad \Psi = \Phi^{-1}, \quad \Phi = \Psi^{-1}.$$

It may be shown that in this case the product of Φ and Ψ is commutative as indicated and that the reciprocal of either is uniquely determined.

The reciprocal of a product may be shown to be the product of the reciprocals taken in inverse order, that is,

(14) $$(\Phi\Psi\Omega)^{-1} = \Omega^{-1}\Psi^{-1}\Phi^{-1}.$$

The reciprocal may be written down immediately. For if

(15) $$\Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \ldots + \nu|\bar{\nu}, \quad (-1)^{n-1}\Phi^{-1} = \bar{\alpha}'|\alpha' + \bar{\beta}'|\beta' + \ldots + \bar{\gamma}'|\nu'.$$

[1] The proofs of these statements are so simple and so like those given for the simpler case in the Vector Analysis, chapter 5, that there is no need of giving them here. The same is true of a large number of propositions which follow. See also Whitehead's Universal Algebra.

The existence of a reciprocal for any complete dyadic establishes the principle of cancelation for such dyadics. Thus

$$\text{if } \Phi\Psi = \Phi\Omega \text{ then } \Phi^{-1}\Phi\Psi = \Phi^{-1}\Phi\Omega \text{ and } \Psi = \Omega$$

$$\text{or if } \Phi\varrho = \Phi\sigma \text{ then } \Phi^{-1}\Phi\varrho = \Phi^{-1}\Phi\sigma \text{ and } \varrho = \sigma.$$

In the first of these equations the second dyadic Φ or Ω need not be complete. Although a complete dyadic may be canceled from an equation, an incomplete generally cannot be canceled.

A dyadic may be multiplied into itself; the product $\Phi\Phi$ will be denoted by Φ^2. In like manner all the successive powers may be formed. From the theorem on nullity, it follows that if a dyadic is complete, all its powers will be complete. As the reciprocal of any power of a dyadic is the same as that power of the reciprocal, it is seen that negative as well as positive integral exponents are applicable to complete dyadics. Incomplete dyadics will be considered to have only positive powers. It may happen that the successive powers have an increasing degree of nullity, so that there is a certain least power p such that $\Phi^p = 0$. In this case Φ is said to be a nilpotent dyadic. It is not necessary, however, that the nullity of the successive powers should increase to the value n. This may be seen by a simple example. Consider the dyadic

$$\Phi = \alpha|\alpha' + \beta|\beta' + \ldots + \lambda|\lambda', \quad (l < n \text{ terms}).$$

This has nullity of degree $n-l$, and as all its powers are identical with it, they also have nullity of degree $n-l$. In general, however, the powers of an incomplete dyadic have increasing nullities up to a certain power, from which on they all have the same nullity. And by reasoning like that employed in proving Sylvester's theorem on nullities, it is seen at once that if $n-l$, $n-l+l_1$, $n-l+l_1+l_2$, ... are the respective nullities of Φ, Φ^2, Φ^3, ..., then $n-l \geqq l_1 \geqq l_2 \geqq \ldots$. Gibbs apparently did not state this last fact in his lectures.

6. *Homologous dyadics.*—It has been stated that in general, dyadics are not commutative in their multiplication. If two dyadics Φ and Ψ are such that $\Phi\Psi = \Psi\Phi$, they will be said to be homologous. Any dyadic is homologous with the idemfactor I, and all powers of a dyadic are homologous with one another. Moreover, if two or more dyadics are homologous, any dyadics which may be obtained from them by the algebraic processes of addition, multiplication, and so forth, are also homologous with the original dyadics and with each other. Thus the algebra of homologous dyadics does not differ essentially from the algebra of ordinary real and complex numbers except as regards the extraction of roots. It will be seen later, in article 14, that even in such simple cases as the

square roots of the idemfactor, two square roots are not generally homologous. It is possible to define logarithms and exponentials of dyadics, and to show that these are homologous with the original dyadic; but this does not appear to be very useful.[1]

The system of homologous dyadics which is most useful is that which consists of a given dyadic, the idemfactor, and the dyadics derivable by means of rational operations on these two. For instance, let a dyadic Φ satisfy an equation, with scalar coefficients, of the type

$$\Phi^p + a_1 \Phi^{p-1} + \ldots + a_{p-1} \Phi + a_p I = 0, \tag{16}$$

and consider the scalar equation

$$x^p + a_1 x^{p-1} + \ldots + a_{p-1} x + a_p = 0.$$

The roots of this equation may be found and the equation factored into

$$(x - r_1)(x - r_2) \ldots (x - r_p) = 0.$$

So likewise the equation involving Φ may be factored into

$$(\Phi - r_1 I)(\Phi - r_2 I) \ldots (\Phi - r_p I) = 0. \tag{16'}$$

Again, two polynomials in Φ:

$$\Gamma(\Phi) = \Phi^p + a_1 \Phi^{p-1} + \ldots + a_{p-1} \Phi + a_p I$$

and

$$\Delta(\Phi) = \Phi^m + a_1 \Phi^{m-1} + \ldots + a_{m-1} \Phi + a_m I$$

may be divided according to the usual algorithm. If Δ is of lower degree than Γ, the result of the division may be written

$$\Gamma(\Phi) = B(\Phi)\ \Delta(\Phi) + P(\Phi) \tag{17}$$

where the remainder $P(\Phi)$ is a polynomial of degree less than m. Thus the Euclidean algorithm for the highest common factor may be applied to two such polynomials.

Any dyadic Φ may be shown to satisfy a polynomial of degree not greater than n^2. To see this, let Φ be expressed as a block of n^2 terms in the form (9), where the antecedents and consequents are chosen as reciprocal sets. The higher powers of Φ are likewise expressible in terms of the same n^2 dyads and certain combinations of the coefficients c_{ij}. Consider the system of equations, $n^2 + 1$ in number, formed by the first n^2 powers of Φ and the idemfactor. From these equations the n^2 dyads may be eliminated as if they where ordinary variables in $n^2 + 1$ linear equations in n^2 unknowns. The result is obviously an equation of the form

$$c_1 \Phi^{n^2} + c_2 \Phi^{n^2-1} + \ldots + c_{n^2-1} \Phi + c_{n^2} I = 0. \tag{18}$$

As a matter of fact, it will be shown in article 11 that any dyadic Φ satisfies an equation of degree n—the Hamilton-Cayley equation—

[1] See, for instance, The Scientific Papers, volume 2, pp. 78–84. Some simple differential equations are also solved in these pages.

but the existence of this equation is not necessary for many of the theorems concerning polynomials.

As Φ satisfies an equation of degree n^2, it may be inferred that Φ must satisfy an equation of least degree. Let this equation be of degree p, so that

(16″) $$A(\Phi) = \Phi^p + a_1 \Phi^{p-1} + \ldots + a_{p-1} \Phi + a_p I = 0.$$

The equation of least degree is unique. For if there were two different equations of least degree, their difference would be an equation of less degree—which is absurd. It follows that any equation $E(\Phi) = 0$ in Φ must be the product of the equation of least degree and a polynomial in Φ. For it is possible to write, in accordance with (17),

(17′) $$0 = E(\Phi) = B(\Phi)\, A(\Phi) + P(\Phi).$$

Hence $P(\Phi)$ vanishes and the statement is proved. The equation of least degree is therefore a necessary factor of any equation in Φ.

Double Multiplication.

7. *Introduction to double products.*—The developments of the two preceding sections do not differ materially from the ordinary treatments of the generalized linear vector function (Hamilton) or the simplest type of Lückenausdrücke and quotients (Grassmann) or the theory of matrices (Cayley, Sylvester, Frobenius, and others). They have been passed hastily in review, partly for the purpose of outlining Gibbs's course on multiple algebra, partly for the purpose of establishing the notations, methods, and fundamental theorems which will be useful in the future. With his usual reticence, Gibbs apparently did not think that this part of his work on multiple algebra was of sufficient importance and originality to warrant his printing it. With regard to double multiplication it was different. He seemed to feel that here he had introduced a new idea and a new set of methods, which might be of considerable importance in a complete treatment of multiple algebra. In fact I remember that he once told me that he had in mind several points in multiple algebra which he hoped to find time to publish after he had completed the revision of his published papers on thermodynamics. Very likely he was thinking of his theory of double multiplication. Unfortunately, however, the revision of his thermodynamic papers was cut short, almost before it had begun, by his sudden death; and the only portions of his work on double multiplication which were published during his life consist of the few words on the subject in his address On Multiple Algebra and of the discussion

given for the simple case of vectors in the fifth and sixth chapters of the Vector Analysis.

Given two dyadics

$$\Phi = \alpha\,|\,\bar{\alpha} + \beta\,|\,\bar{\beta} + \gamma\,|\,\bar{\gamma} + \ldots,$$
$$\Psi = \alpha_1\,|\,\bar{\alpha}_1 + \beta_1\,|\,\bar{\beta}_1 + \gamma_1\,|\,\bar{\gamma}_1 + \ldots,$$

the combination

$$\begin{aligned}\Phi \overset{\times}{\times} \Psi = {} & \alpha\,\alpha_1\,|\,\bar{\alpha}\,\bar{\alpha}_1 + \alpha\,\beta_1\,|\,\bar{\alpha}\,\bar{\beta}_1 + \alpha\,\gamma_1\,|\,\bar{\alpha}\,\bar{\gamma}_1 + \ldots \\ & + \beta\,\alpha_1\,|\,\bar{\beta}\,\bar{\alpha}_1 + \beta\,\beta_1\,|\,\bar{\beta}\,\bar{\beta}_1 + \beta\,\gamma_1\,|\,\bar{\beta}\,\bar{\gamma}_1 + \ldots \\ & + \gamma\,\alpha_1\,|\,\bar{\gamma}\,\bar{\alpha}_1 + \gamma\,\beta_1\,|\,\bar{\gamma}\,\bar{\beta}_1 + \gamma\,\gamma_1\,|\,\bar{\gamma}\,\bar{\gamma}_1 + \ldots \\ & + \ldots\ldots\ldots\ldots\ldots\ldots\end{aligned}$$

is called the double (combinatory) product of Φ into Ψ. This product will be denoted, as indicated, by inserting a double cross between the dyadics. The value of using a definitive symbol for the combinatory product is thus brought clearly into the foreground as soon as the question of these double products is taken up. Turning the fact that the progressive and regressive products obey the distributive law, it is clear that the value of $\Phi \overset{\times}{\times} \Psi$ does not depend on the particular representation of Φ and Ψ which may be adopted.

From the definition, the double product is obviously distributive. Moreover it is commutative. For the combinatory product of the elements is commutative except for a change of sign, and in the double product there are two changes of sign. Furthermore, the double product of several dyadics is associative, that is,

$$(\Phi \overset{\times}{\times} \Psi) \overset{\times}{\times} \Omega = \Phi \overset{\times}{\times} (\Psi \overset{\times}{\times} \Omega) = \Phi \overset{\times}{\times} \Psi \overset{\times}{\times} \Omega. \tag{20}$$

This follows from the associative property of the combinatory product of the elements. If a double product of more than n dyadics were formed, the laws of regressive multiplication would have to be brought in to determine the meaning of the product. The work that follows will, therefore, be restricted to the consideration of double products of n or fewer dyadics. In accordance with the definitions given in article 4, the double product of two (primary) dyadics is a secondary dyadic; the double product of three dyadics is a dyadic of the third class; and so on. The double product of n dyadics is a scalar. The definition of double products may clearly be extended to the product of dyadics other than primary, provided that the class of the product does not exceed n.[1])

[1] It may be noted that in the Vector Analysis, p. 308, the double product (with a cross) of two dyadics is stated to be non-associative. This is because, from the point of view of the Vector Analysis, the combinatory product of two vectors is not regarded as a quantity of the

8. *Double powers.*—A dyadic may be multiplied doubly into itself. Thus if

$$\Phi = \alpha\,\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \dots$$

then

$$\begin{aligned}\Phi \overset{\times}{\times} \Phi = {} & \alpha\beta|\bar{\alpha}\bar{\beta} + \alpha\gamma|\bar{\alpha}\bar{\gamma} + \dots \\ & + \beta\alpha\,\bar{\beta}\bar{\alpha} + \beta\gamma|\bar{\beta}\bar{\gamma} + \dots \\ & + \gamma\alpha|\bar{\gamma}\bar{\alpha} + \gamma\beta|\bar{\gamma}\bar{\beta} + \dots \\ & + \dots\dots\dots\end{aligned} \tag{21}$$

It will be noticed that the terms in $\Phi \overset{\times}{\times} \Phi$ occur in pairs. The expression

$$\Phi_2 = \tfrac{1}{2}\,\Phi \overset{\times}{\times} \Phi = \tfrac{1}{2}\,\Phi \overset{2}{\overset{\times}{\times}}. \tag{22}$$

which is one-half of $\Phi \overset{2}{\overset{\times}{\times}}$, will be denoted, as indicated, by Φ_2. It may be called the double square of Φ or, more briefly and properly, the second of Φ. In like manner the expressions

$$\Phi_3 = \tfrac{1}{3!}\,\Phi \overset{\times}{\times} \Phi \overset{\times}{\times} \Phi = \tfrac{1}{3!}\,\Phi \overset{3}{\overset{\times}{\times}},\ \Phi_4 = \tfrac{1}{4!}\,\Phi \overset{4}{\overset{\times}{\times}},\ \dots,\ \Phi_n = \tfrac{1}{n!}\,\Phi \overset{n}{\overset{\times}{\times}} \tag{22'}$$

may be formed and will be called the third of Φ, the fourth of Φ, ..., the nth of Φ. Collectively the set $\Phi_2, \Phi_3, \dots, \Phi_n$ may be called the double powers of Φ, although it should be remembered that in Φ_k the factor $\frac{1}{k!}$ has been inserted.

The double powers afford a ready means of formulating the conditions that a dyadic Φ possess a certain degree of nullity without the necessity of reducing Φ to the sum of the fewest possible dyads—a reduction which is by no means easily carried out on any assigned dyadic. If the dyadic has $n-l$ degrees of nullity, it may be written as

$$\Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \dots + \lambda|\bar{\lambda} \quad (l \text{ terms}),$$

where the antecedents and consequents are independent. In this case Φ_l takes the form

$$\Phi_l = (\alpha\,\beta\,\gamma\,\dots\,\lambda)\,(\bar{\alpha}\,\bar{\beta}\,\bar{\gamma}\,\dots\,\bar{\lambda}) \tag{23}$$

and does not vanish. All the higher double powers will vanish because one element will have to be repeated in each antecedent and consequent. The lower powers cannot vanish; for the double pro-

second class, but as a vector, and vector multiplication is not associative. Moreover, in the Vector Analysis, the scalar product of two vectors occurs, and hence there is the double scalar product of two dyadics. If Grassmann's inner product were introduced into the system in addition to his outer product (the combinatorial product), there would be double inner products of dyadics. These were not taken up in Gibbs's course, and they will be omitted at this point.

duct of a zero dyadic into any dyadic is zero, and Φ_l is not zero. Hence the necessary and sufficient condition that Φ have $n-l$ degrees of nullity is that

$$\Phi_l \neq 0, \qquad \Phi_{l+1} = 0. \tag{23'}$$

This condition may be applied directly to Φ without any previous reduction.

The geometric interpretation of the successive double powers is important. Suppose the dyadic is written as a sum of n terms with independent consequents, so that

$$\Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \dots .$$

This dyadic converts the vectors $\bar{\alpha}'$, $\bar{\beta}'$, $\bar{\gamma}'$, ... into the vectors α, β, γ, ... (or their negatives).[1] The second of Φ has the form

$$\begin{aligned} \Phi = \alpha\beta|\bar{\alpha}\bar{\beta} + \alpha\gamma|\bar{\alpha}\bar{\gamma} + \dots \\ + \beta\gamma|\bar{\beta}\bar{\gamma} + \dots \\ + \dots . \end{aligned} \tag{21'}$$

This (secondary) dyadic converts the elements $\bar{\alpha}'\bar{\beta}'$, $\bar{\alpha}'\bar{\gamma}'$, $\bar{\beta}'\bar{\gamma}'$, ... of the second class into the elements $\alpha\beta$, $\alpha\gamma$, $\beta\gamma$, ... Elements of the second class are the geometric counterpart of plane areas, namely the area of the parallelograms of which the vectors which correspond to the primary elements are the sides. Hence, if Φ represents the transformation of vectors in space of n dimensions, Φ_2 represents the transformation of two dimensional plane areas in that space. In like manner Φ_3 represents the transformation of three-dimensional volumes in the space, and so on until Φ_n which gives the ratio in which n-dimensional volumes are changed.

A considerable number of formulas for operation with double powers may be readily deduced. To show that

$$(\Phi\,\Psi)_2 = \Phi_2\,\Psi_2 \tag{24}$$

let Φ be expressed as a sum of n dyads with independent consequents $\bar{\alpha}$, $\bar{\beta}$, $\bar{\gamma}$, ... and let Ψ be expressed as a sum of n dyads with the reciprocals of these consequents as antecedents.

$$\begin{aligned} \Phi &= \alpha|\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \dots , \\ \Psi &= \bar{\alpha}'|\bar{\lambda} + \bar{\beta}'|\bar{\mu} + \bar{\gamma}'|\bar{\nu} + \dots . \end{aligned}$$

Then $$(-1)^{n-1}\,\Phi\,\Psi = \alpha|\bar{\lambda} + \beta|\bar{\mu} + \gamma|\bar{\nu} + \dots .$$

It is merely necessary to form the expression for $\Phi_2\,\Psi_2$ and $(\Phi\,\Psi)_2$ to see that they are immediately identical. The same method may be used to show that $(\Phi\,\Psi)_k = \Phi_k\,\Psi_k$. By an obvious generalisation it follows that the kth of a product of any number of factors is the product of the $k$ths of those factors, that is,

[1] It is scarcely necessary to mention that, geometrically speaking, the dyadic Φ represents a homogeneous strain about fixed origin.

(24′) $$(\Phi\,\Psi\,\Omega\,\ldots)_k = \Phi_k\,\Psi_k\,\Omega_k\,\ldots\,.$$

As a corollary it is seen that $(\Phi^n)_k = (\Phi_k)^n = \Phi_k^n$. The formula given in article 5 for the reciprocal of a dyadic may be used to extend this result to negative exponents in case Φ is complete.

If Φ and Ψ are homologous dyadics, the developments of article 6 show that the expansion of

$$(\Phi+\Psi)^n = \Phi^n + n\,\Phi^{n-1}\,\Psi + \frac{n\,(n-1)}{2\,!}\,\Phi^{n-2}\,\Psi^2 + \ldots + \Psi^n$$

may be carried on by the ordinary binomial theorem. It the dyadics are not homologous, this will no longer be true: the second term, for instance will consist of n terms in which Φ occurs $n-1$ times and Ψ once, but the rearrangement which permits of writing $n\,\Phi^{n-1}\,\Psi$ will be impossible. There is, however, a binomial theorem for the kth of a sum, namely,

(25) $$(\Phi+\Psi)_k = \Phi_k + \Phi_{k-1}\overset{\times}{\times}\Psi + \Phi_{k-2}\overset{\times}{\times}\Psi_2 + \ldots + \Psi_k.$$

The proof consists in considering the expansion of $(\Phi+\Psi)^{\overset{k}{\times}}$. As the commutative and associative laws hold for double products, it is possible to write

$$(\Phi+\Psi)^{\overset{k}{\times}} = \Phi^{\overset{k}{\times}} + k\,\Phi^{\overset{k-1}{\times}}\overset{\times}{\times}\Psi + \frac{k\,(k-1)}{2\,!}\,\Phi^{\overset{k-2}{\times}}\overset{\times}{\times}\Psi^{\overset{2}{\times}} + \ldots$$

$$= k\,!\;\Phi_k + k\,.\,(k-1)\,!\;\Phi_{k-1}\overset{\times}{\times}\Psi + k\,(k-1)\,.\,(k-2)\,!\;\Phi_{k-2}\overset{\times}{\times}\Psi_2 + \ldots\,.$$

On dividing through by $\frac{1}{k\,!}$ the theorem is proved. It will be noticed that the usual binomial coefficients are lacking in the binomial theorem for double products.

9. *Conjugate dyadics.*—The conjugate of a given primary dyadic is a dyadic which satisfies the condition

(26) $$\varrho\,\Phi_c = \Phi\,\varrho,\quad \Phi_c = (-1)^{n-1}(\bar{\alpha}|\alpha + \bar{\beta}|\beta + \ldots) \text{ if } \Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \ldots$$

for all values of the quantity ϱ. It is denoted by a subscript c. The dyadic Φ_c is not primary, but of the class $n-1$. The necessity for the negative sign arises when n is even, because then $\bar{\alpha}\,\varrho = -\,\varrho\,\bar{\alpha}$. In the definition of conjugates for dyadics of the second and higher classes, the factor $(-1)^{n-1}$ is applied only in the case of dyadics of odd class; for it is only in such cases that the reversed of the order of the factors changes the sign. The idemfactors $I,\ I_2,\ I_3,\ \ldots,\ I_{n-1},\ I_n = 1$, which are mentioned in article 3, and which are the appropriate idemfactors respectively for elements of the first, second, third, ... $(n-1)$st, and nth classes, as may be

seen from the work on double multiplication, satisfy the obvious equations

(27) $\quad I = I_{n-1,c},\ I_2 = I_{n-2,c},\ \ldots\ ,\ I_{n-2} = I_{2c},\ I_{n-1} = I_c.$

The conjugate of the conjugate of any dyadic is the given dyadic, that is $(\Phi_c)_c = \Phi$. The process of taking the conjugate is involutory.

As to the rules of operation with conjugates, a number of theorems may be stated. The conjugate of the sum of any dyadics is the sum of the conjugates. The conjugate of the product of two dyadics is the product of the conjugates taken in inverse order. For let

$$\Phi = \alpha\,\bar{\alpha} + \beta\,\bar{\beta} + \gamma\,\bar{\gamma} + \ldots\ ,$$
$$\Psi = \bar{\alpha}'|\lambda + \bar{\beta}'|\mu + \bar{\gamma}'|\nu + \ldots\ .$$

By merely forming the expression for $(\Phi\,\Psi)_c$ and $\Psi_c\,\Phi_c$ the truth of the theorem is evident in this case. The proof for dyadics other than primary would be similar, and the theorem may evidently be extended to any number of factors by induction. Hence the conjugate of any power of a dyadic is that same power of the conjugate of the dyadic, and the result may be extended to negative powers if a reciprocal exists. It may also be seen that the double product of the conjugates of two or more dyadics is the conjugate of the double product of the dyadics. Here the order of the factors is immaterial. As a special case, the conjugate of a double power is that double power of the conjugate.

As Φ_c and Φ_{n-1} are both of the $(n-1)$st class, it is natural to seek a relation between them. Let

$$\Phi = \alpha|\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \ldots + \nu|\bar{\nu}\ ,\ (n \text{ terms})$$

Now Φ_{n-1} is the sum of all combinations (not permutations, for the factor $\frac{1}{(n-1)!}$ has been thrown out) of $n-1$ antecedents and their corresponding consequents. These combinations may be represented in terms of the reciprocal sets provided that the dyadic Φ is complete so that the antecedents and consequents are linearly independent. Thus in this case

$$\Phi_{n-1} = (\alpha\,\beta\,\gamma\,\ldots\,\nu)\,(\bar{\alpha}\,\bar{\beta}\,\bar{\gamma}\,\ldots\,\bar{\nu})\,(\alpha'\,\bar{\alpha}' + \beta'\,\bar{\beta}' + \gamma'\,\bar{\gamma}' + \ldots + \nu'|\bar{\nu}')$$

and $\Phi_c = (-1)^{n-1}\,(\bar{\alpha}|\alpha + \bar{\beta}|\beta + \bar{\gamma}|\gamma + \ldots + \bar{\nu}|\nu)$

The negative sign occurs in precisely those cases where the theory of reciprocals in article 3 requires it. Hence

(28) $\qquad \Phi_c\,\Phi_{n-1} = \Phi_n\,I_{n-1}.$

If Φ has one or more degrees of nullity, it may be written as the sum of $n-1$ dyads, which need not have independent antecedents and consequents, unless the degree of nullity is one; and hence

Φ_{n-1} consists of a single term containing all the antecedents. The product $\Phi_c \Phi_{n-1}$ is therefore null. In this case Φ_n is evidently also null, and equation (28) must therefore hold for all cases.

The demonstration just given for the relation between Φ_c and Φ_{n-1} would evidently apply with only insignificant alterations to establishing a similar relation between Φ_{2c} and Φ_{n-2}, Φ_{3c} and Φ_{n-3}, and so on. Hence the general formula

$$(\Phi_k)_c \, \Phi_{n-k} = \Phi_n \, I_{n-k} \tag{29}$$

On taking the conjugate of each side, the formula

$$\Phi_k \, (\Phi_{n-k})_c = \Phi_n \, I_k \tag{29'}$$

is found. In case Φ has no degree of nullity, these equations may be solved. Hence

$$\Phi_k = \Phi_n \left(\Phi_{n-k}^{-1}\right)_c \quad \text{or} \quad \Phi_k^{-1} = (\Phi_{n-k})_c \,/\, \Phi_n. \tag{30}$$

The formulas represented in (29′) look much like the successive double powers of the formula for $k = 1$, which is

$$\Phi \, (\Phi_{n-1})_c = \Phi_n \, I. \tag{28'}$$

If the ordinary rules of forming successive double powers be applied formally, the result is

$$(\Phi \, \Phi_{n-1}, c)_2 = \Phi_n^2 \, I_2, \; (\Phi \, \Phi_{n-1}, c)_3 = \Phi_n^3 \, I_3, \ldots$$

or

$$\Phi_2 \, (\Phi_{n-1})_2, c = \Phi_n^2 \, I_2, \; \Phi_3 \, (\Phi_{n-1})_3, c = \Phi_n^3 \, I_3, \ldots .$$

A comparison with (29′) would apparently yield the result

$$(\Phi_{n-1})_2 = \Phi_n \Phi_{n-2}, \qquad (\Phi_{n-1})_3 = \Phi_n^2 \, \Phi_{n-3}, \ldots . \tag{31}$$

The justification for such procedure, however, would involve the discussion of double powers of order greater than n.

Invariant Properties of Dyadics.

10. *The scalar invariants.*—Let a dyadic Φ be written as the sum of any number of dyads:

$$\Phi = \alpha \, \bar{\alpha} + \beta \, \bar{\beta} + \gamma \, \bar{\gamma} + \ldots .$$

Suppose that the vertical bar which serves to keep the elements of the dyads apart, be removed and the sign of the combinatorial product be inserted in its place (again the value of having a sign such as $\times$ for the combinatorial product is brought out) so that the antecedent and consequent of the dyad coalesce into a scalar. The sum of these scalars, taken with the proper sign, obtained from each dyad will be called the scalar of the dyadic and written[1]

$$(-1)^{n-1} \, \Phi_s = \alpha \, \bar{\alpha} + \beta \, \bar{\beta} + \gamma \, \bar{\gamma} + \ldots . \tag{32}$$

[1] The sign is negative when the negative sign is called for in equation (5″).

The value of this scalar depends only on the dyadic and not at all on the particular representation which has been used. This is due to the fact that both dyadic and combinatorial products obey the distributive law. Such scalars may be obtained regardless of the class to which the dyadic belongs. In particular, the double powers yield the n scalars

(33) $$\Phi_s\,,\ \Phi_{2s}\,,\ \ldots\,,\ \Phi_{n-1,\,s},\ \Phi_n,$$

where the subscript s has been omitted in the case of Φ_n which is a scalar.

The scalar of the conjugate of a dyadic is the same as the scalar of the dyadic: for the negative sign which sometimes enters into the definition of the conjugate occurs in precisely those instances in which the reversal of the order of the factors would introduce a change in the sign of the combinatory product. The scalar of the product of two dyadics satisfies the equation

(34) $$(\Phi\,\Psi)_s = \Phi \overset{\times}{\times} \Psi_c$$

Perhaps the easiest way to see this is to consider both Φ and Ψ expanded into a block of n^2 terms of the form (9) where the antecedents and consequents are reciprocal sets and are the same for both expansions. Then $(\Phi\,\Psi)_s$ is obviously the sum of the products of pairs of coefficients symmetrically situated with respect to the main diagonals, one taken from one of the dyadics and the other from the other. The same rule applies for evaluating $\Phi \overset{\times}{\times} \Psi_c$, and hence the two expressions are equal. It may be seen directly, or by the application of the rules for conjugates and double products, that

(35) $$(\Psi\,\Phi)_s = (\Phi\,\Psi)_s\,.$$

A more general theorem is that the scalar of the product of any number of factors is unchanged by a cyclic permutation of the factors. The proof in the case of three factors is contained in the equations

(35′) $$(\Phi\,\Psi\,\Omega)_s = [(\Phi\,\Psi)\,\Omega]_s = (\Phi\,\Psi) \overset{\times}{\times} \Omega_c = \Omega_c \overset{\times}{\times} (\Phi\,\Psi) =$$
$$\Omega \overset{\times}{\times} (\Phi\,\Psi)_c = (\Omega\,\Phi\,\Psi)_s\,;$$

the proof for a greater number of factors is by induction. This result may be used to put the matter of invariance of the scalar of a dyadic in a different light. Consider any linear transformation of coordinates. This may be represented by a dyadic Ψ. Under this transformation, the strain represented by Φ becomes

(36) $$\Omega = \Psi\,\Phi\,\Psi^{-1}$$

and $$\Omega_s = (\Psi\,\Phi\,\Psi^{-1})_s = (\Phi\,\Psi^{-1}\Psi)_s = \Phi_s,$$

and hence it appears that none of the n scalar invariants of any

dyadic differs from the corresponding invariants of the transformed dyadic.[1]

By virtue of the identity $\Phi_k = \Phi_k I_k$, it appears that

$$\Phi_{k\,s} = (\Phi_k I_k)_s = \Phi_k \overset{\times}{\times} I_{k\,c} = \Phi_k \overset{\times}{\times} I_{n-k}. \tag{37}$$

This may be taken as the definition of $\Phi_{k\,s}$ in place of (32) and analogous equations, and it offers a ready interpretation of the scalar invariants of Φ according to the matricular form (9) in which the antecedents and consequents are reciprocal sets. In this case Φ_s is merely the sum of all the coefficients in the main diagonal; $\Phi_{2\,s}$ is the sum of all two-rowed minors of the matrix which have two terms of the main diagonal as their main diagonal; $\Phi_{3\,s}$ is the sum of all three-rowed minors which have the three terms of their main diagonal selected from the terms of the main diagonal of the matrix; and so on until finally Φ_n is the determinant of the matrix. The values of these sums would be unchanged if the matrix underwent a transformation of coordinates. The importance of these invariants to the theory of matrices and to the mathematical theories of elasticity is well known. It would be possible indefinitely to multiply the interpretation of the theory of dyadics in the theory of matrices by reference to the expression of the dyadics in the form (9) where the antecedents and consequents are reciprocal sets: but this would not be worth while.

11. *The identical equation.*—It was shown in article 6 that any dyadic satisfies an equation of degree not greater than n^2, and from this fact was deduced the existence of an equation of least degree. Consider the relation (28′) of article 9 as applied to the dyadic $\Phi - g I$, where Φ is any dyadic and g is any scalar.

$$(\Phi - g I)_n I = (\Phi - g I)(\Phi - g I)_{n-1,\,c}$$

The left-hand side may be expanded by the binomial theorem (25) and simplified by the relations (37); the right-hand side may also be expanded by the binomial theorem and then multiplied out. The result is

$$[\Phi_n - g\,\Phi_{n-1,\,s} + g^2\,\Phi_{n-2,\,s} - \ldots + \overset{n-1}{(-1)}\,g^{n-1}\,\Phi_s + \overset{n}{(-1)}\,g^n]\,I = \Pi(g),$$

where $\Pi(g)$ is a polynomial of degree n in g with dyadic coefficients. The relation is an identity in g. By the same reasoning which shows that two identical algebraic polynomials with scalar

[1] The relation of a dyadic to its family of transformed dyadics $\Psi\,\Phi\,\Psi{-}1$, where Ψ is any complete dyadic, was apparently left unmentioned by Gibbs. Perhaps this was due merely to the brevity of his course on multiple algebra.

coefficients must have equal coefficients, it may be seen that two identical polynomials with dyadic coefficients must have identical coefficients. Therefore not only may any scalar be put in the place of g, but any vector or dyadic may be put in its place without disturbing the identity. If Φ be substituted for g, the righthand side vanishes. Hence

$$\Phi^n - \Phi_s \Phi^{n-1} + \Phi_{2s} \Phi^{n-2} - \ldots + (-1)^{n-1} \Phi_{n-1,\ s} \Phi + (-1)^n \Phi_n I = 0. \tag{38}$$

This is the identical equation which any dyadic must satisfy. It is sometimes called the Hamilton-Cayley equation.

The actual equation of the coefficients of the different powers of g gives the dyadic equations

$$\begin{gathered}
\Phi\ \Phi_{n-1,\,c} = \Phi_n I \\
\Phi_{n-1,\ c} + (\Phi_{n-2} \overset{\times}{\times} I)_{\ c} = \Phi_{n-1,\,s}\ I, \\
(\Phi_{n-2} \overset{\times}{\times} I)_c + \Phi\ (\Phi_{n-3} \overset{\times}{\times} I_2)_{\ c} = \Phi_{n-2,\ s}\ I \\
\ldots\ldots\ldots\ldots\ldots\ldots \\
(\Phi_2 \overset{\times}{\times} I_{n-3})_{\ c} + \Phi\ (\Phi \overset{\times}{\times} I_{n-2})_{\ c} = \Phi_{2\,s}\ I \\
(\Phi \overset{\times}{\times} I_{n-2})_{\ c} + \Phi = \Phi_s\ I
\end{gathered} \tag{39}$$

If the relation $(\Phi - g\ I)_n\ I_2 = (\Phi - g\ I)_2\ (\Phi - g\ I_{n-2,\ c})$ had been used, the same identical equation of the matrix would have been found, but the equations obtained from comparing coefficients would have been

$$\begin{gathered}
\Phi \overset{\times}{\times} I_{n-2,\,c} + \Phi_2\ (\Phi_{n-3} \overset{\times}{\times} I)_{\ c} = \Phi_{n-1,\ s}\ I_2 \\
\Phi_{n-2,\ c} + \Phi \overset{\times}{\times} I\ (\Phi_{n-3} \overset{\times}{\times} I)_{\ c} + \Phi_3\ (\Phi_{n-4} \overset{\times}{\times} I_2)_{\ c} = \Phi_{n-2,\ s}\ I_2 \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
(\Phi_2 \overset{\times}{\times} I_{n-4})_{\ c} + \Phi \overset{\times}{\times} I\ (\Phi \overset{\times}{\times} I_{n-3})_{\ c} + \Phi_2 = \Phi_{2\ s}\ I_2 \\
(\Phi \overset{\times}{\times} I_{n-3})_{\ c} + \Phi \overset{\times}{\times} I = \Phi_s\ I_2
\end{gathered} \tag{39'}$$

Consider the scalar equation, called the characteristic equation,

$$x_n - \Phi_s\, x^{n-1} + \Phi_{2\,s}\, x^{n-2} - \ldots + (-1)^{n-1}\, \Phi_{n-1,\ s}\, x + (-1)^n\, \Phi_n = 0, \tag{40}$$

and suppose the roots are a, b, c, ... with the multiplicities p, q, r, ... The identical equation (38) may then be factored into

$$(\Phi - a\, I)^p\ (\Phi - b\, I)^q\ (\Phi - c\, I)^r \ldots = 0. \tag{38'}$$

As the scalar equation may be regarded as the expansion of $(\Phi - x\, I)_n$, it appears that each of the factors $\Phi - a\, I$, $\Phi - b\, I$, $\Phi - c\, I$, ... must have at least one degree of nullity, that is, there must be at least one element α such that $(\Phi - a\, I)\ \alpha = 0$ or $\Phi\ \alpha = a\ \alpha$, etc. The roots a, b, c, ... of the scalar equation are called the latent roots

of the dyadic. There is at least one element fixed except as to magnitude for each latent root of Φ.

If any element is a fixed element (except for magnitude will be understood) corresponding to the latent root a, no product of the form

$$\Pi(\Phi) = (\Phi - bI)^q (\Phi - cI)^r \dots \tag{41}$$

can annihilate the element. For by direct substitution it is seen that

$$\Pi\alpha = \alpha (a-b)^q (a-c)^r \dots$$

In like manner, if β is an element which satisfies the equation $(\Phi - aI)^p \beta = 0$ but does not satisfy the equation $(\Phi - aI)^{p-1}\beta = 0$, then $(\Phi - aI)^{p-1}\beta$ is a fixed element corresponding to the root a, and no product of the above type (41) can annihilate it. It follows, therefore, that factors of the type $(\Phi - aI)^p$, $(\Phi - cI)^q$, ... are entirely independent in their nullities, and the product of such terms has the same nullity as the sum of the nullities of the factors. It appears also that the equation of lowest degree must contain each of the factors of the type $\Phi - aI$, $\Phi - bI$, ... at least once, or there would be some elements which would not be annihilated by the product. The equation of least degree may therefore be written as

$$A(\Phi) = (\Phi - aI)^{p'} (\Phi - bI)^{q'} (\Phi - cI)^{r'} \dots = 0, \tag{42}$$

$$p' \leq p,\ q' \leq q,\ r' \leq r, \dots,$$

where none of the exponents vanish and the degree of the equation is not greater than n.

12. *The reduction of a dyadic.*—With his usual desire for general hypotheses, Gibbs made no use of the Hamilton-Cayley equation and the resulting fact that the degree of the equation of least degree is not greater than n when he came to reduce the dyadic to a canonical form. He based his work on the existence of an equation of least degree as proved in (16) of article 6. Suppose this equation were factored by the methods indicated in that article. Let the equation be

$$A(\Phi) = (\Phi - aI)^p (\Phi - bI)^q (\Phi - cI)^r \dots, \tag{43}$$

and let

$$p + q + r + \dots = m.$$

Further let

$$\Phi - aI = \Psi,\ \Phi - bI = \Psi + (a-b)I,\ \Phi - cI = \Psi + (a-c)I, \dots. \tag{44}$$

Then

$$(\Phi - bI)^q (\Phi - cI)^r \dots = AI + B\Psi + C\Psi^2 + \dots + H\Psi^{m-p}, \tag{45}$$

where

$$A = (a-b)^q (a-c)^r \dots \neq 0.$$

Divide $AI + B\Psi + C\Psi^2 + \dots + H\Psi^{m-p}$ into I by the ordinary

algorithm and carry the division up to and including the power Ψ^{p-1} in the quotient. Then

$$(46)\qquad \frac{I}{A\,I+B\,\Psi+\ldots+H\,\Psi^{m-p}} = A'\,I+B'\Psi+\ldots+E'\,\Psi^{p-1} + \frac{\Psi^{p}\,P(\Psi)}{A\,I+B\,\Psi+\ldots+H\,\Psi^{m-p}}$$

where $P(\Psi)$ is a polynomial of degree $m-p-1$ in Ψ. Set

$$(47)\qquad I_a = (A\,I+B\,\Psi+\ldots+H\,\Psi^{m-p})\,(A'\,I+B'\,\Psi\ldots+E'\,\Psi^{p-1}) = I-\Psi^{p}\,P(\Psi).$$

In like manner compute I_b, I_c, ... corresponding to the values b, c, ...

The dyadic I_a does not contain Ψ^p as a factor; for it is $I-\Psi^p\,P(\Psi)$. It does, however, contain $(\Psi-b\,I)^q\,(\Psi-c\,I)^r\ldots$, which represents the other factors of the equation of least degree. Hence $I_a\,\Psi^p$ contains the equation of least degree and vanishes. Hence

$$I_a^2 = I_a\,[I-\Psi^p\,P(\Psi)] = I_a-I_a\,\Psi^p\,P(\Psi) = I_a.$$

The product $I_a\,I_b$ contains in I_a all the factors of the equation of least degree except $(\Psi-a\,I)^q$ and in I_b it contains those. Hence $I_a\,I_b = 0$. Thus

$$(48)\qquad I_a^2 = I_a,\ I_b^2 = I_b,\ I_c^2 = I_c,\ \ldots,\qquad I_a\,I_b = 0,\ I_a\,I_c = 0,\ I_b\,I_c = 0,\ \ldots.$$

Let Ω be the sum

$$(49)\qquad \Omega = I_a + I_b + I_c + \ldots.$$

It follows that

$$\Omega^2 = \Omega \quad \text{or} \quad (\Omega-I)\,\Omega = 0.$$

This expression is a polynomial in Ψ and is equal to zero. It must contain the equation of least degree as shown in article 6. But Ω contains no factor of this equation, because any factor such as $\Psi-a\,I$ is contained in all the I's except I_a. Hence all the factors of the equation of least degree must be contained in $\Omega-I$. As $\Omega-I$ is of degree $m-1$ in Ψ, which is less than that of the equation of least degree, the only possibility is

$$(50)\qquad \Omega-I \equiv 0 \quad \text{and} \quad \Omega = I.$$

Suppose I_a, I_b, I_c, ... written as the sum of the fewest possible number of dyads, so that

$$(51)\qquad I_a = \alpha|\bar{\alpha}+\beta|\bar{\beta}+\gamma|\bar{\gamma}+\ldots,\qquad I_b = \lambda|\bar{\lambda}+\mu|\bar{\mu}+\nu|\bar{\nu}+\ldots.$$

. . . . . .

Then if I_a^2 be compared with I_a,

$$I_a^2 = (\bar{\alpha}\,\alpha)\,\alpha|\bar{\alpha}+(\bar{\alpha}\,\beta)\,\alpha|\bar{\beta}+(\bar{\alpha}\,\gamma)\,\alpha|\bar{\gamma}+\ldots + (\bar{\beta}\,\beta)\,\beta|\bar{\beta}+(\bar{\beta}\,\alpha)\,\beta|\bar{\alpha}+(\bar{\beta}\,\gamma)\,\beta|\bar{\gamma}+\ldots + \ldots$$

it follows that

$$\bar{\alpha}\,\alpha = \bar{\beta}\,\beta = \bar{\gamma}\,\gamma = \ldots = 1, \quad \bar{\alpha}\,\beta = \bar{\beta}\,\alpha = \bar{\alpha}\,\gamma = \bar{\gamma}\,\alpha = \bar{\beta}\,\gamma = \ldots = 0.$$

Furthermore the equation $I_a\, I_b = 0$ gives

$$\bar{\alpha}\,\lambda = \bar{\lambda}\,\alpha = \bar{\alpha}\,\mu = \bar{\mu}\,\alpha = \bar{\beta}\,\lambda = \ldots = 0.$$

And if any linear relation existed between the antecedents of the different I's such as

$$\sigma = a\,\alpha + b\,\beta + l\,\lambda + m\,\mu + \ldots + \ldots = 0,$$

there would result the equation

$$I_a\,\sigma = a\,\alpha + b\,\beta + \ldots = 0,$$

which contradicts the hypothesis that I_a is expressed as the sum of the fewest possible number of dyads. And similarly in the case of the consequents. Hence the total number of dyads in all the I's cannot exceed n; and on the other hand, as their sum is the idemfactor, it cannot be less than n. Hence the sets

$\alpha, \beta, \gamma, \ldots, \lambda, \mu, \nu, \ldots, \ldots$ and $\bar{\alpha}, \bar{\beta}, \bar{\gamma}, \ldots, \bar{\lambda}, \bar{\mu}, \bar{\nu}, \ldots, \ldots$

are reciprocal, that is

$$(51') \qquad I_a = \alpha|\alpha' + \beta|\beta' + \gamma|\gamma' + \ldots$$
$$I_b = \lambda|\lambda' + \mu|\mu' + \nu|\nu' + \ldots$$

Next consider the expression

$$(52) \quad \Phi = \Phi\, I = \Phi\,(I_a + I_b + I_c + \ldots) = \Phi_a + \Phi_b + \Phi_c + \ldots$$

The dyadics $\Phi_a, \Phi_b, \Phi_c, \ldots$ have the property

$$(52') \qquad \Phi_a\,\Phi_b = \Phi_a\,\Phi_c = \Phi_b\,\Phi_c = \ldots = 0,$$

owing to the presence of the factors $I_a, I_b, I_c, \ldots$. The dyadic Φ has now been resolved into the sum of as many dyadics as there are latent roots. These are all homologous with one another and with the original dyadic. The equations

$$(52'') \qquad \Phi_a = I_a\,\Phi\,I_a, \quad \Phi_b = I_b\,\Phi\,I_b, \ldots$$

which follow from this fact, shows that $\Phi_a, \Phi_b, \ldots$ have the same antecedents and consequents as $I_a, I_b, \ldots$. Hence if Φ be expressed in the form (9) where the antecedents and consequents are reciprocal sets, it follows that Φ will consist of a series of matrices strung along the main diagonal and equal in number to the number of latent roots. The further discussion of Φ may be restricted to the treatment of these individual dyadics $\Phi_a, \Phi_b, \ldots$. The question of the reduction of a dyadic to standard form has been reduced to the single case in which the dyadic has only one latent root.

Gibbs then reduced dyadics with only one latent root to a matricular form in which the terms underneath the main diagonal disappear. This reduction, however, is not complete, and consequently a modified form of it will be given. It may be pointed out that the above reduction of Φ to a sum of independent dyadics is in no way dependent on the completeness of Φ. The result is equally

valid for incomplete dyadics. If the dyadic Φ be arranged in matricular form with no terms beneath the main diagonal, the existence of the Hamilton-Cayley equation is evident. Finally it may be noted that the reduction yields the same form for all of the transformed dyadics of Φ. For if Φ satisfies the equation

$$A(\Phi) = \Phi^m + A_1\,\Phi^{m-1} + \ldots + A_{m-1}\,\Phi + A_m\,I = 0,$$

then

$$(54)\quad \begin{aligned} A(\Psi\Phi\Psi^{-1}) &= (\Psi\Phi\Psi^{-1})^m + A_1(\Psi\Phi\Psi^{-1})^{m-1} + \ldots A_{m-1}\,\Psi\Phi\Psi^{-1} \\ &\qquad + A_m\,I \\ &= \Psi\Phi^m\,\Psi^{-1} + A_1\Psi\Phi^{m-1}\,\Phi^{-1} + \ldots + A_{m-1}\,\Psi\Phi\Psi^{-1} \\ &\qquad + A_m\,I \\ &= \Psi A(\Phi)\,\Psi^{-1} = 0. \end{aligned}$$

It is obvious that this proof could have been given just as well in article 6, and that in particular the equation of least degree is identical for all the transformed dyadics $\Psi\,\Phi\,\Psi^{-1}$. The fact that the scalar invariants of $\Psi\,\Phi\,\Psi^{-1}$, as shown in article 10, are identical with those of Φ shows that the Hamilton-Cayley equations are the same in both cases. The remaining steps to fill in for the purpose of establishing the identity of the reduction of Φ and $\Psi\,\Phi\,\Psi^{-1}$ are too obvious to need detail.

13. *The canonical form of a dyadic.*—The equation of least degree gives the relation

$$(54)\quad (\Phi - a\,I)^p\,I_a = 0 \text{ or } (\Phi - a\,I)^p\,I_a{}^p = 0 \text{ or } (\Phi a - a\,I_a)^p = 0$$

For brevity let

$$(55)\qquad \Phi_a - a\,I_a = Z.$$

The further classification and reduction of dyadics therefore depends on the classification and reduction of nilpotent dyadics. Consider the successive powers

$$(56)\qquad Z, Z^2, Z^3, \ldots, Z^{p-1}, Z^p = 0.$$

These have increasing nullities, but the change of nullity between two successive powers never increases. This may be expressed as

$$(57)\qquad \begin{gathered} Z_k^{p-1} \neq 0,\ Z_{k+k_1}^{p-2} \neq 0,\ \ldots\ Z^2{}_{k+k_1+\ldots+k_{p-3}} \neq 0, \\ Z_{k+k_1+\ldots+k_{p-2}} \neq 0. \end{gathered}$$

where, by the theorem at the end of article 5,

$$(58)\qquad k \leqq k_1 \leqq k_2 \leqq \ldots \leqq k_{p-2} \leqq k_{p-1}$$

and

$$k + k_1 + k_2 + \ldots + k_{p-2} + k_{p-1} = m,$$

if m be the multiplicity of the root a, where it is understood that the next higher double powers of each dyadic must vanish. The subscripts therefore denote the number of independent dyads in the dyadics. It remains to show that, with the aid of these relations,

which correspond to each of the latent roots. It is hardly necessary at this point to indicate the relation of this result to the theory of elementary divisors. Another matter which will be passed without examination is the reduction of a real dyadic to a real canonical form. This is not of importance to the work that follows and it was not treated in any detail by Gibbs. All that is essential in his treatment of dyadics, as given in his course on multiple algebra, has now been set forth.

Part II.—Some algebraic and geometric applications.

Square Roots of the Idemfactor.

14. *Involutory strains.*—If a strain represented by Φ be involutory, its square is the identical transformation and analytically

$$\Phi^2 = I, \qquad (\Phi - I)(\Phi + I) = 0. \tag{66}$$

Any dyadic which satisfies this equation may be called a square root of the idemfactor. The algebraic theory of these square roots and the geometric theory of involutory strains correspond, and each may be used to study the other.[1] Equation (66) is clearly of lowest degree, and the latent roots are $+1$ and -1. As the individual factors enter the equation of lowest degree only to the first power, the reduction is

$$\Phi_{(+1)} = I_{(+1)} = \alpha_1|\alpha'_1 + \alpha_2|\alpha'_2 + \ldots \alpha_k|\alpha'_k,$$
$$\Phi_{(-1)} = I_{(-1)} = \alpha_{k+1}|\alpha'_{k+1} + \ldots + \alpha_n|\alpha'_n.$$

Hence

$$\Phi = I_{(+1)} - I_{(-1)} = \sum_1^k \alpha_i|\alpha'_i - \sum_{k+1}^n \alpha_i|\alpha'_i \tag{67}$$

There are $n+1$ different types of these roots according as Φ contains 0, 1, 2, . . . , $n-1$, or n negative signs. The first and last are

[1] The relation of involutory strains to the group of unimodular strains in the simple case where $n = 3$ has been treated in detail by me in an article entitled Oblique reflections and unimodular strains, Transactions of the American Mathematical Society, volume 8, pp. 270–298, 1907. Reference to the case of three dimensions will be to this article. A number of references to the literature of involutory transformations may be found there or in my article Involutory transformations in the projective group and in its subgroups, The Annals of Mathematics, second series, volume 8, pp. 77–86, 1907, where only the most general questions are discussed.

respectively the idemfactor and its negative; and the other types occur in pairs, namely, 1 and $n-1$, 2 and $n-2$, ... which differ only by the factor -1. The number of square roots of type k is $\infty 2k(n-k)$. Another form in which Φ may be expressed is

$$\Phi = \pm (I - 2\sum_{1}^{k} \alpha_i | \bar{\alpha}_i), \qquad k \leqq E\left(\frac{n}{2}\right), \tag{68}$$

where $E\left(\frac{n}{2}\right)$ is the integral part of $\frac{n}{2}$ and where the relations

$$\bar{\alpha}_i \cdot \alpha_i = 1, \qquad \bar{\alpha}_i \cdot \alpha_j = 0 \tag{68'}$$

hold. For some purposes this form is more convenient. It should be remarked that what is important is not the individual antecedents and the individual consequents, but the spaces

$$R_k(\alpha_1, \alpha_3, \ldots, \alpha_k) \qquad R_{n-k}(\bar{\alpha}_1, \bar{\alpha}_2, \ldots, \bar{\alpha}_k)$$

of k and of $n-k$ dimensions which are determined by them. It is clear that the spaces R_k and R_{n-k} are invariant under the transformation Φ; the former having all vectors identically fixed and the latter having all vectors reversed in direction or vice versa, according as the $-$ or the $+$ sign is taken with the parenthesis.

To consider the transformation of vectors in general, it will be best to resolve the vectors along the two fixed spaces. Then the component along the space identically fixed will remain fixed, and the other component will be reversed in direction. It is clear that if either of the fixed spaces be taken with all the dimensions of the other fixed space except one, the result be a space of $n-1$ dimensions which will be fixed. The volume of an n-dimensional region is not changed in magnitude or in sign by the even types 0, 2, ...; and is changed only in sign by the odd types 1, 3 ... As the transformations may evidently be regarded as a generalisation of reflection, namely a reflection through the space $R_k(\alpha_1, \alpha_2, \ldots \alpha_k)$ parallel to the space $R_{n-k}(\bar{\alpha}_1, \bar{\alpha}_2, \ldots, \bar{\alpha}_k)$ or vice versa, according as the $-$ or $+$ sign is used, the designation 'oblique reflection' or merely 'reflection' will be applied to the geometric counterpart of the square roots of the idemfactor. In case the volume does not change sign the reflection will be called proper, in other cases it will be called improper. And these terms will be used to apply to dyadics in general; if $\Phi_n > 0$, the dyadic is a proper dyadic, and if $\Phi_n < 0$, it is improper.

If two square roots of the idemfactor are to be homologous, they must be commutative. It is a general theorem in transformations that the necessary and sufficient condition that the product of two involutory transformations be commutative, is that it shall itself be involutory. Hence two square roots of I will be hom-

which correspond to each of the latent roots. It is hardly necessary at this point to indicate the relation of this result to the theory of elementary divisors. Another matter which will be passed without examination is the reduction of a real dyadic to a real canonical form. This is not of importance to the work that follows and it was not treated in any detail by Gibbs. All that is essential in his treatment of dyadics, as given in his course on multiple algebra, has now been set forth.

Part II.—Some algebraic and geometric applications.

Square Roots of the Idemfactor.

14. *Involutory strains.*—If a strain represented by Φ be involutory, its square is the identical transformation and analytically

$$\Phi^2 = I, \qquad (\Phi - I)(\Phi + I) = 0. \tag{66}$$

Any dyadic which satisfies this equation may be called a square root of the idemfactor. The algebraic theory of these square roots and the geometric theory of involutory strains correspond, and each may be used to study the other.[1] Equation (66) is clearly of lowest degree, and the latent roots are $+1$ and -1. As the individual factors enter the equation of lowest degree only to the first power, the reduction is

$$\Phi_{(+1)} = I_{(+1)} = \alpha_1|\alpha'_1 + \alpha_2|\alpha'_2 + \ldots \alpha_k|\alpha'_k,$$
$$\Phi_{(-1)} = I_{(-1)} = \alpha_{k+1}|\alpha'_{k+1} + \ldots + \alpha_n|\alpha'_n.$$

Hence

$$\Phi = I_{(+1)} - I_{(-1)} = \sum_{1}^{k} \alpha_i|\alpha'_i - \sum_{k+1}^{n} \alpha_i|\alpha'_i \tag{67}$$

There are $n+1$ different types of these roots according as Φ contains 0, 1, 2, . . . , $n-1$, or n negative signs. The first and last are

[1] The relation of involutory strains to the group of unimodular strains in the simple case where $n = 3$ has been treated in detail by me in an article entitled Oblique reflections and unimodular strains, Transactions of the American Mathematical Society, volume 8, pp. 270–298, 1907. Reference to the case of three dimensions will be to this article. A number of references to the literature of involutory transformations may be found there or in my article Involutory transformations in the projective group and in its subgroups, The Annals of Mathematics, second series, volume 8, pp. 77–86, 1907, where only the most general questions are discussed.

respectively the idemfactor and its negative; and the other types occur in pairs, namely, 1 and $n-1$, 2 and $n-2$, ... which differ only by the factor -1. The number of square roots of type k is $\infty 2k(n-k)$. Another form in which Φ may be expressed is

$$\Phi = \pm (I - 2\sum_{1}^{k} \alpha_i | \bar{\alpha}_i), \qquad k \leqq E\left(\frac{n}{2}\right), \tag{68}$$

where $E\left(\frac{n}{2}\right)$ is the integral part of $\frac{n}{2}$ and where the relations

$$\bar{\alpha}_i \cdot \alpha_i = 1, \quad \bar{\alpha}_i \cdot \alpha_j = 0 \tag{68'}$$

hold. For some purposes this form is more convenient. It should be remarked that what is important is not the individual antecedents and the individual consequents, but the spaces

$$R_k(\alpha_1, \alpha_2, \ldots, \alpha_k) \qquad R_{n-k}(\bar{\alpha}_1, \bar{\alpha}_2, \ldots, \bar{\alpha}_k)$$

of k and of $n-k$ dimensions which are determined by them. It is clear that the spaces R_k and R_{n-k} are invariant under the transformation Φ; the former having all vectors identically fixed and the latter having all vectors reversed in direction or vice versa, according as the $-$ or the $+$ sign is taken with the parenthesis.

To consider the transformation of vectors in general, it will be best to resolve the vectors along the two fixed spaces. Then the component along the space identically fixed will remain fixed, and the other component will be reversed in direction. It is clear that if either of the fixed spaces be taken with all the dimensions of the other fixed space except one, the result be a space of $n-1$ dimensions which will be fixed. The volume of an n-dimensional region is not changed in magnitude or in sign by the even types 0, 2, ...; and is changed only in sign by the odd types 1, 3 ... As the transformations may evidently be regarded as a generalisation of reflection, namely a reflection through the space $R_k(\alpha_1, \alpha_2, \ldots \alpha_k)$ parallel to the space $R_{n-k}(\bar{\alpha}_1, \bar{\alpha}_2, \ldots, \bar{\alpha}_k)$ or vice versa, according as the $-$ or $+$ sign is used, the designation 'oblique reflection' or merely 'reflection' will be applied to the geometric counterpart of the square roots of the idemfactor. In case the volume does not change sign the reflection will be called proper, in other cases it will be called improper. And these terms will be used to apply to dyadics in general; if $\Phi_n > 0$, the dyadic is a proper dyadic, and if $\Phi_n < 0$, it is improper.

If two square roots of the idemfactor are to be homologous, they must be commutative. It is a general theorem in transformations that the necessary and sufficient condition that the product of two involutory transformations be commutative, is that it shall itself be involutory. Hence two square roots of I will be hom-

ologous when and only when their product is a square root of I. As the involutory strains of types 0 and n are respectively $+I$ and $-I$, they may be excluded as trivial when referring to the product of two. As the product is I when and only when the two roots are identical, that case may also be laid aside. In the case of two dimensions the only involutory transformation is $\alpha|\alpha' - \beta|\beta'$. The determinant is negative and hence the determinant of the product is positive. The product is therefore $-I$, and it is seen that the line through which the reflection takes place in one is the line parallel to which it takes place in the other, and vice versa. In three dimensions there is a line and a plane entering into the characterisation of any involutory transformation, and unless the product of two is to be I, it is necessary and sufficient that the line of one reflection lie in the plane of the other and vice versa if the product is to be commutative.

Consider next the case of n dimensions. Let Φ denote an involutory transformation and let Ω by any transformation which is commutative with it. Then

$$\Phi\,\Omega = \Omega\,\Phi \quad \text{or} \quad \Omega\,\Phi\,\Omega^{-1} = \Phi.$$

And $$\Phi = \alpha_n|\alpha'_n + \alpha_{n-1}|\alpha'_{n-1} + \ldots + \alpha_{k-1}|\alpha'_{k+1} - \alpha_k|\alpha'_k - \ldots - \alpha_1|\alpha'_1.$$

If Ω carries $\alpha_1, \alpha_2, \ldots, \alpha_n$ into $\beta_1, \beta_2, \ldots, \beta_n$,

$$\Omega = \beta_1|\alpha'_1 + \beta_2|\alpha'_2 + \ldots + \beta_n|\alpha'_n$$

and $$\Omega\,\Phi\,\Omega^{-1} = \beta_n|\beta'_n + \beta_{n-1}|\beta'_{n-1} + \ldots + \beta_{k+1}|\beta'_{k+1} - \beta_k|\beta'_k - \ldots - \beta_1|\beta'_1.$$

If this is to be identical with Φ, the spaces R_k $(\beta_1, \beta_2, \ldots, \beta_k)$ and R_k $(\alpha_1, \alpha_2, \ldots, \alpha_k)$ must coincide, and also the spaces R_{n-k} $(\beta_{k+1}, \ldots, \beta_n)$ and R_{n-k} $(\alpha_{k+1}, \ldots, \alpha_n)$. Now if it be involutory, the transformation between the β's and α's in R_k must be involutory; and so must the transformation between the β's and α's in R_{n-k}. If $\gamma_1, \gamma_2, \ldots, \gamma_k$ and $\gamma_{k+1}, \ldots, \gamma_n$ be the fixed elements of the involutory transformation Ω, it is seen that they all lie in the fixed spaces R_k and R_{n-k}. A different way of stating the result is this. Let

$$\Phi = \pm\,(I - 2\sum_1^k \alpha_i|\bar{\alpha}_i) \quad \text{and} \quad \Psi = \pm\,(I - 2\sum_1^l \beta_i|\bar{\beta}_i), \quad k,\ l \leqq E\left(\frac{n}{2}\right),$$

with the spaces R_k, R_{n-k} and S_l, S_{n-l}. Suppose R_k and S_l intersect in T_m. Then if the product $\Phi\,\Psi = \Psi\,\Phi$ is involutory, R_k intersects S_{n-l} in R'_{k-m} and S_l intersects R_{n-r} in S'_{l-m} and the space $V_{k+l-2\,m}$ compounded of R'_{k-m} and S'_{l-m} is fixed in the product. Furthermore R_{n-k} and S_{n-l} will have in common a space $T_{n-k-l+m}$ which compounded with T_m gives $V_{n-k-l+2\,m}$ as a fixed space of

the product. Which of the spaces $V_{k+l-2\,m}$ and $V_{n-k-l+2\,m}$ is identically fixed and which is involutorily fixed depends on the sign of $\Phi\,\Psi$. If the sign is $+$, $V_{n-k-l+2m}$ is identically fixed. The problem of determining the conditions under which two square roots of I are homologous may therefore be considered as solved.

15. *The product of two involutory transformations.*—Next consider the product of any two involutory transformation, $\Omega = \Psi\,\Phi$, where

$$\Phi = \pm\,(I - 2\sum_{1}^{k} \alpha_i|\bar{\alpha}_i) \qquad k \leqq E\left(\frac{n}{2}\right) \tag{69}$$

$$\Psi = \pm\,(I - 2\sum_{1}^{l} \beta_i|\bar{\beta}_i) \qquad l \leqq E\left(\frac{n}{2}\right)$$

As Φ and Ψ are their own reciprocals, $\Omega^{-1} = \Phi\,\Psi$ by (14). Hence by (35)

$$\Omega_k^{-1}{}_s = (\Phi_k\,\Psi_k)_s = (\Phi_k\,\Psi_k)_s = \Omega_{k\,s}. \tag{70}$$

On substitution from the relations (30), there results

$$\Omega_{ks} = \Omega_n\,\Omega_{n-k,\,s}, \qquad \Omega_n = \pm\,1. \tag{70'}$$

There arise, then, four different cases of the scalar or characteristic equation (40):

$$\begin{aligned}
&x^n - \Omega_s\,x_{n-1} + \Omega_{2\,s}\,x^{n-2} - \ldots - \Omega_{2\,s}\,x^2 + \Omega_s\,x - 1 = 0, && \text{n odd}, \ \Omega_n > 0,\\
&x^n - \Omega_s\,x^{n-1} + \Omega_{2\,s}\,x^{n-2} - \ldots + \Omega_{2\,s}\,x^2 - \Omega_s\,x + 1 = 0, && \text{n even}, \Omega_n > 0,\\
&x^n - \Omega_s\,x^{n-1} + \Omega_{2\,s}\,x^{n-2} - \ldots + \Omega_{2\,s}\,x^2 - \Omega_s\,x + 1 = 0, && \text{n odd}, \ \Omega_n < 0,\\
&x^n - \Omega_s\,x^{n-1} + \Omega_{2\,s}\,x^{n-2} - \ldots - \Omega_{2\,s}\,x^2 + \Omega_s\,x - 1 = 0, && \text{n even}, \Omega_n < 0,
\end{aligned} \tag{71}$$

according as n is odd or even and Ω proper or improper. The first three of these equations are reciprocal equations, the last is not, unless $\Omega_{\frac{n}{2}\,s} = 0$. Thus, if a dyadic can be written as the product of two square roots of the idemfactor, the scalar equation is reciprocal except in the case that n is even and the determinant of the dyadic is negative. This case is treated later.

If the number of dimensions is odd, the determinant of $-I$ is negative. Hence the third case in the above list may be reduced to the first case by making the simple change of Ω to $-\Omega$. Moreover, if the question of interest were to decide whether, given a reciprocal scalar equation, every dyadic which satisfied it were resoluble into two reflections, it would be sufficient to answer the question for dyadics of positive determinant, in case n is odd, inasmuch as $-I$ is commutative with any dyadic. In the fourth case, it would be possible to replace Ω by $\Omega\,(I - \alpha|\bar{\alpha})$ or by Ω times any reflection of determinant -1. But here nothing is gained, because the product $\Omega\,(I - \alpha|\bar{\alpha})$ may not satisfy an equation of the

second type. In fact, when $n = 2$, a dyadic which satisfies an equation of the type $x^2 + ax - 1 = 0$ is not in general resoluble into two reflections. The case of the fourth type must be examined more in detail.

Consider the product of two reflections in an even number of dimensions and let the determinant of the product be negative. It is evident that the two reflections cannot be the same. In fact if the types are k and l, it is necessary and sufficient that $k + l$ be odd in order that the determinant of the product be negative. The product may then be written in the form

$$\Omega = \pm (I - 2 \sum_1^k \beta_i \bar{\beta}_i)\ (I - 2 \sum_1^l \alpha_i \bar{\alpha}_i), \qquad l + k < n.$$

The spaces $\bar{\beta}_1, \bar{\beta}_2, \ldots, \bar{\beta}_k, \bar{\alpha}_1, \bar{\alpha}_3, \ldots, \bar{\alpha}_l$ of the consequents are therefore together greater than n and must intersect. The transformation of vectors in this space of intersection is either identical or is such as to reserve the direction of each vector without introducing any other change. In the former case $+1$ and in the latter case -1 is a root of the scalar equation. On substituting either of these values in the fourth equation of (71), if is seen that $\Omega_{n-2} S = 0$. In other words it appears from special considerations that the equation of the fourth type is also reciprocal if Ω is the product of two reflections. As there is this additional condition in this case, the question might arise whether there were not also additional conditions in other cases.

This question may be phrased as follows: Given any reciprocal equation

$$(72) \qquad x_n - a_1 x^{n-1} + a_2 x^{n-2} - \ldots \pm \frac{1}{a_2} x^2 \mp \frac{1}{a_1} x \pm 1 = 0$$

of degree n, can a dyadic Ω be found such that

$$(73) \quad \Omega_s = a_1, \quad \Omega_{2\,s} = a_2, \ \ldots, \quad \Omega_{n-2,\,s} = \pm \frac{1}{a_2}, \quad \Omega_{n-1,\,s} = \pm \frac{1}{a_1},$$
$$\Omega_n = \pm 1$$

and such that Ω may be written as the product of two square roots of I? Suppose that the roots of (72) with their respective multiplicities are

$$r_1, r_1^{-1}, m_1; \ r_2, r_2^{-1}, m_2; \ r_3, r_3^{-1}, m_3; \ \ldots; \ r_h, r_h^{-1}, m_h;$$

The dyadic which has these roots may be written as

$$(74) \quad \Omega = r_1 \alpha_1 | \alpha'_1 + r_1 \alpha_2 | \alpha'_2 + \ldots r_1 \alpha_{m_1} | \alpha'_{m_1} + r_2 \alpha_{m_1+1} | \alpha'_{m_1+1}$$
$$+ r_2 \alpha_{m_1+2} | \alpha'_{m_1+2} + \ldots .$$
$$+ r_1^{-1} \beta_1 | \beta'_1 + r_1 \beta_2 | \beta'_2 + \ldots + r_1^{-1} \beta_{m_1} | \beta'_{m_1} + r_2^{-1} \beta_{m_1+1} | \beta'_{m_1+1}$$
$$+ r_2^{-1} \beta_{m_1+2} | \beta'_{m_1+2} + \ldots .$$

$$+ \alpha_1|\alpha'_2 + \alpha_2|\alpha'_3 + \ldots + \alpha_{m_1+1}|\alpha'_{m_1+2} + \ldots$$
$$+ \beta_1|\beta_2 + \beta_2|\beta'_3 + \ldots + \beta_{m_1+1}|\beta'_{m_1+2} + \ldots$$

where the shearing terms in the last two rows may or may not occur; and such a dyadic will evidently satisfy the relations (73), It remains to ascertain whether Ω is resoluble as desired.

The answer is negative. For suppose that $\Omega = \Psi\Phi$, where Φ and Ψ are involutory. It has been seen in article 12 that the equation of lowest degree is the same for the set of dyadics which are the transformeds of a given dyadic. Now if Ω satisfies the equation

(75) $\Omega^p - b_1\Omega^{p-1} + b_2\Omega^{p-2} - \ldots \pm b_{p-2}\Omega^2 \mp b_{p-1}\Omega \pm 1 = 0, \quad p < n,$

of least degree, so will $\Phi\Omega\Phi^{-1}$. But as Φ and Ψ are involutory,

$$\Phi\Omega\Phi^{-1} = \Phi\Psi = \Omega^{-1},$$

and

(75′) $$(\Omega^{-1})^p - b_1(\Omega^{-1})^{p-1} + b_2(\Omega^{-1})^{p-2} - \ldots \pm b_{p-2}(\Omega^{-1})^2 \mp b_{p-1}\Omega^{-1} \pm 1 = 0.$$

Hence, to extend the use of the term reciprocal to equations in dyadics, it may be stated that if a dyadic is the product of two square roots of the idemfactor, its equation of lowest degree is reciprocal. This is stating more than equations (72): for the dyadic (74) would not in general have an equation of lowest degree which was reciprocal. If the equation of lowest degree is reciprocal, the factors $\Omega - aI$, $\Omega - \frac{1}{a}I$ which correspond to a pair of reciprocal roots a, $\frac{1}{a}$ of the scalar equation must enter to the same degree. Moreover, from the results of article 13 it is seen that the invariant numbers k, k_1, k_2, $\ldots$, k_{p-1} are the same for a dyadic and its transformed dyadics. It is therefore clear that the invariant numbers which correspond to two roots a, $\frac{1}{a}$ must be equal in case the dyadic is the product of two square roots of I. The question now is whether these conditions are sufficient for such a resolution.

Consider the spaces $R(\alpha_1, \alpha_2, \ldots, \alpha_{m_1}, \beta_1, \beta_2, \ldots, \beta_{m_1})$ and $S(\alpha_{m_1+1}, \ldots, \beta_{m_1+1} \ldots)$, made up of the antecedents which correspond to any root and its reciprocal and of all other antecedents. These spaces are fixed and moreover the space R and the space S are independent and together contain n independent directions. The transformation in two such spaces will determine the transformation in all space. But the transformation in each of these two spaces is such that its scalar equation would also be reciprocal. If now the transformation in these spaces of dimension less than n

can be resolved into two reflections, the transformation in n-dimensional space may be so resolved by merely combining the elements through which the transformation takes place in the two spaces R, S and the elements along which it takes place. Thus the question has been reduced to the same question for a fewer number of dimensions provided that there are two independent fixed spaces R and S in Ω.

There remains to consider only the cases where there is just one pair of reciprocal roots $a, \frac{1}{a}$ or one root which is either $+1$ or -1. The first of these arises when n is even and the type of both reflections is $\frac{n}{2}$ with the n consequents of the two reflections and the n antecedents each independent. However, if there is only one pair of reciprocal roots, the dyadic may be written in the form

$$(76)\quad \Omega = a\,\alpha_1|\alpha'_1,\ a\,\alpha_2|\alpha'_2 + \ldots + a\,\alpha_{\frac{n}{2}}|\alpha'_{\frac{n}{2}} + a^{-1}\beta_1|\beta'_1 + a^{-1}\beta_2|\beta_2' + \ldots + a^{-1}\beta_{\frac{n}{2}}|\beta'_{\frac{n}{2}}$$
$$+ \alpha_1|\alpha'_2 \quad + \alpha_2|\alpha'_2 + \ldots \quad + \beta_1|\beta'_1 + \beta_2|\beta'_2 \ldots,$$

where it must be assumed that the shearing terms which occur in the second row are equal in number for both roots and are similarly distributed. Moreover it may be assumed that none of them are lacking, namely, that their number is $n-2$: for otherwise the reasoning just given for different pairs of roots would apply. The transformation may be written in oblique coordinates as

$$(76')\quad x'_1 = a x_1,\ x'_2 = a x_2 + x,\ \ldots,\ x'_{\frac{n}{2}} = a x_{\frac{n}{2}} + a x_{\frac{n}{2}-1},$$
$$y'_1 = \frac{1}{a} y_1,\ y'_2 = \frac{1}{a} y_2 + y_1,\ \ldots,\ y'_{\frac{n}{2}} = \frac{1}{a} y_{\frac{n}{2}} + y_{\frac{n}{2}-1}.$$

This transformation leaves a quadratic form invariant. For consider the terms

$$(77)\quad A_{11}\ x_1y_1 + A_{21}\ x_2y_1 + A_{31}\ x_3y_1 + \ldots + A_{n\,\frac{n}{2}-1}\ x_n y_{\frac{n}{2}}$$
$$+ A_{12}\ x_1y_3 + \ldots + A_{n\,\frac{n}{2}-2}\ x_{\frac{n}{2}-1}\ y_1 + 0$$
$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$+ A_{1,\frac{n}{2}-3}\ x_1y_{\frac{n}{2}-3} + A_{2,\frac{n}{2}-3}\ x_2y_{\frac{n}{2}-3} + A_{3,\frac{n}{2}-3}\ x_3y_{\frac{n}{2}-3} + A_{4,\frac{n}{2}-3}\ x_4y_{\frac{n}{2}-3} \ldots 0$$
$$+ A_{1,\frac{n}{2}-2}\ x_1y_{\frac{n}{2}-2} + A_{2,\frac{n}{2}-2}\ x_2y_{\frac{n}{2}-2} + A_{3,\frac{n}{2}-2}\ x_3y_{\frac{n}{2}-2} \quad 0 \ldots \ldots 0$$
$$+ A_{1,\frac{n}{2}-1}\ x_1y_{\frac{n}{2}-1} + A_{2,\frac{n}{2}-1}\ x_2y_{\frac{n}{2}-1} \quad 0 \ldots\ldots\ldots\ldots 0$$
$$+ A_{1,\frac{n}{2}}\ x_1y_{\frac{n}{2}} \quad 0 \quad 0 \ldots\ldots\ldots\ldots 0.$$

Any term $A_{ij}\, x_i\, y_j$ may arise only from the possible combinations of

$$x'_i = a x_i + x_{i-1}, \quad x'_{i+1} = a x_{i+1} + x_i$$

and

$$y'_j = \frac{1}{a} y_j + y_{j-1}, \quad y'_{j+1} = \frac{1}{a} y_{j+1} + y_j.$$

If $A_{ij}\, x_i\, y_j$ is to be an invariant term, the relation

$$A_{ij} + \frac{1}{a}\, A_{i+1,\, j} + a\, A_{i,\, j+1} + A_{i+1,\, j+1} = A_{ij} \tag{78}$$

must hold. If this be applied to any of the zero terms, it is seen that they yield nothing. If it be applied to the terms in the main diagonal it is seen that they an invariant. If it be applied to any of the terms in the diagonal next above the main diagonal, there is established a set of conditions imposed upon the terms of the main diagonal, namely,

$$A_{1,\, \frac{n}{2}} : A_{2,\, \frac{n}{2}-1} : A_{3,\, \frac{n}{2}-2} : A_{4,\, \frac{n}{2}-3} : \ldots = 1 : -a^2 : a^4 : -a^6 : \ldots$$

If it be applied to the terms in the next diagonal line, these arises a condition to be imposed on the coefficients in the diagonal next to the main diagonal, and so on. These conditions are such that they may obviously be solved for the ratios of the coefficients in the successive diagonal lines. The result in case of six variables $x_1, x_2, x_3, y_1, y_2, y_3$ gives a quadratic form of the type (stars indicate the possible presence of terms)

	x_1	x_2	x_3	y_1	y_2	y_3
x_1	0	0	0	*	*	1
x_2	0	0	0	*	$-a^2$	0
x_3	0	0	0	a^4	0	0
y_1	*	*	a^4	0	0	0
y_2	*	$-a^2$	0	0	0	0
y_3	1	0	0	0	0	0

of which the determinant is clearly not zero; and a similar form may be written down for any even number of variables. Now, Smith [1] has shown that the transformation of a quadratic form with itself may always be resolved into the product of two involutory transformations. Hence the dyadic (76) may be factored into the product of two square roots of I.

[1] P. F. Smith, On the linear transformations of a quadratic form into itself, Transactions of the American Mathematical Society, volume 6, pp. 1–16 (1905). The theorem here referred to is found on p. 13. The more detailed exposition of the relations between collineations and strains is taken up in our next article 16.

In case there is only one root $+1$, it may be assumed that the dyadic takes the form

(79) $\alpha|\alpha'+\alpha|\beta'+\beta|\beta'+\beta|\gamma'+\gamma|\gamma'+\gamma|\delta'+\delta|\delta'+\delta|\varepsilon'+\varepsilon|\varepsilon'+\ldots,$

in which all the shearing terms occur: for if any of them were absent, a reduction to two spaces of lower dimensions could be effected as in the case of two pairs of roots. This may be factored. In case $n=2$,

(80) $\alpha|\alpha'+\alpha|\beta'+\beta|\beta'=(\alpha|\alpha'-\beta|\beta')\,(\alpha|\alpha'+\alpha|\beta'-\beta|\beta')$

where each of the factors is a square root of I. In case $n=3$,

(80′) $$\alpha|\alpha'+\alpha|\beta'+\beta|\beta'+\beta|\gamma'+\gamma|\gamma'=$$
$$(\alpha|\alpha'-\beta|\beta'+\beta|\gamma'+\gamma|\gamma')\,(\alpha|\alpha'+\alpha|\beta'-\beta|\beta'+\gamma|\gamma')$$

with similar remarks. Again in case $n=4$, the factors are

(80″) $\alpha|\alpha'+\alpha|\beta'+\beta|\beta'+\beta|\gamma'+\gamma|\gamma'+\gamma|\delta'+\delta|\delta'=(\alpha|\alpha'-\beta|\beta'+\beta\gamma'+\gamma|\gamma'-\delta|\delta'-2\gamma|\delta'-\beta|\delta')\,(\alpha|\alpha'+\alpha|\beta'-\beta|\beta'+\gamma|\gamma'-\gamma|\delta-\delta|\delta').$

If the root were -1, the factors would be respectively

$$-\alpha|\alpha'+\alpha|\beta'-\beta|\beta'=(\alpha|\alpha'-\beta|\beta')(-\alpha|\alpha'+\alpha|\beta'+\beta|\beta'),$$

(80‴) $$-\alpha|\alpha'+\alpha|\beta'-\beta|\beta'+\beta|\gamma'-\gamma|\gamma'$$
$$=(\alpha|\alpha'-\beta|\beta'-\beta|\gamma'+\gamma|\gamma')\,(-\alpha|\alpha'+\alpha|\beta'+\beta|\beta'-\gamma|\gamma'),$$

$-\alpha|\alpha'+\alpha|\beta'-\beta|\beta'+\beta|\gamma'-\gamma|\gamma'+\gamma|\delta'-\delta|\delta'=(\alpha|\alpha'-\beta|\beta'-\beta|\gamma'+\gamma|\gamma'-\delta|\delta'+2\gamma|\delta'-\beta|\delta')\,(-\alpha|\alpha'+\alpha|\beta'+\beta|\beta'-\gamma|\gamma'-\gamma|\delta'+\delta|\delta').$

Although this method of factoring could be carried on to higher dimensions, it is better to proceed in another way, which at the same time will indicate how the factors may be obtained if they are not evident. Consider, for example, the case of seven dimensions, where

(79′) $$\alpha|\alpha'+\alpha|\beta'+\beta|\beta'+\beta|\gamma'+\gamma|\gamma'+\gamma|\delta'+\delta|\delta'+\delta|\varepsilon'+\varepsilon|\varepsilon'$$
$$+\varepsilon|\zeta'+\zeta|\zeta'+\zeta|\eta'+\eta|\eta'$$

and note that the two expressions

(81) $$\alpha|\alpha'+\alpha|\beta'-\beta|\beta'+\gamma|\gamma'+\gamma|\delta'-\delta|\delta'+\varepsilon|\varepsilon'+\varepsilon|\zeta'$$
$$-\zeta|\zeta'+\eta|\eta'$$
$$\alpha|\alpha'-\beta|\beta'+\beta|\gamma'+\gamma|\gamma'-\delta|\delta'+\delta|\varepsilon'+\varepsilon|\varepsilon'-\zeta|\zeta'+\zeta|\eta'+\eta|\eta'$$

are obviously square roots of I and that their product has the form

(79″) $$\alpha|\alpha'+\alpha|\beta'+\beta|\beta'+\beta|\gamma'+\gamma|\gamma'+\gamma|\delta'+\delta|\delta'+\delta|\varepsilon'+\varepsilon|\varepsilon'$$
$$+\varepsilon|\zeta'+\zeta|\zeta'+\zeta|\eta'+\eta|\eta'+\beta|\delta'+\delta|\zeta'.$$

This fails to be identical with (79′) owing to the extra terms $\beta|\delta'+\delta|\zeta'$. Nevertheless it belongs to the same type of dyadic as that. In fact it is true that when a dyadic has been reduced to the form (64), which in matricular expression means that the only terms occurring are those of the main diagonal and some (the shearing terms) along the diagonal next above it, then the addition of any terms in the half-square whose diagonal is constructed of the p terms $\alpha_i|\alpha'_i+\beta_i|\beta'_i+\gamma_i|\gamma'_i+\ldots$, $1\leqq i\leqq k$, or of the $p-1$ terms

$\alpha_i|\alpha'_i + \beta_i|\beta'_i + \gamma_i|\gamma'_i + \ldots$, $k+1 \leqq i \leqq k_1$, and so forth, does not effect the nullities of Z, Z^2, Z^3, ... and hence does not alter the type of the dyadic. Hence if the transformation which carries (79″) into (79′) be obtained and applied to the factors (81), the factors will take the desired form.

From the preceding analysis it is seen that in every case either Ω may be factored or may be referred to similar transformations in a less number of dimensions. As the proof that any dyadic which satisfies a reciprocal equation has been given when $n=2$ and when $n=3$,[1] it follows that: The necessary and sufficient condition that a dyadic Φ be factorable into two square roots of the idemfactor (or geometrically, that a strain be resoluble into two oblique reflections) is that the scalar invariants

$$\Phi_s,\ \Phi_{2s},\ \ldots,\ \Phi_{n-1,s},\ \Phi_n = \pm 1$$

be such that the scalar equation is reciprocal and that the sets of invariant numbers

$$k,\ k_1,\ \ldots,\ k_{p-2},\ k_{p-1}$$

which correspond to any root and its reciprocal be equal. This is the generalisation of the result I obtained for the case $n=3$.

16. *Relations between strains and collineations.*—If a strain in n dimensions be written as a matrix by chosing the antecedents and consequents as reciprocal systems, so that

$$\begin{aligned}(82)\qquad \Omega = {} & c_{11}\,\alpha_1|\alpha'_{12} + c_1\,\alpha_1|\alpha'_2 + \ldots + c_{1n}\,\alpha_1|\alpha'_n \\ & + c_{21}\,\alpha_2|\alpha'_1 + c_{22}\,\alpha_2|\alpha'_2 + \ldots + c_{2n}\,\alpha_2|\alpha'_n \\ & + \ldots\ldots\ldots\ldots\ldots\ldots \\ & + c_{n1}\,\alpha_n|\alpha'_2 + c_{n2}\,\alpha_n|\alpha'_2 + \ldots + c_{nn}\,\alpha_n|\alpha'_n\end{aligned}$$

and $\varrho = x_1\,\alpha_1 + x_2\,\alpha_2 + \ldots + x_n\,\alpha_n$

the transformation $\varrho' = \Omega\,\varrho$ in oblique coordinates becomes

$$\begin{aligned}(82')\qquad x'_1 &= c_{11}x_1 + c_{12}x_2 + \ldots + c_{1n}x_n \\ x'_2 &= c_{21}x_1 + c_{21}x_2 + \ldots + c_{2n}x_n \\ &\ldots\ldots\ldots\ldots \\ x'_n &= c_{n1}x_1 + c_{n2}x_2 + \ldots + c_{nn}x_n\end{aligned}$$

---

[1] It should be noted that in these cases the additional condition that the invariant numbers be equal for reciprocal roots is fulfilled necessarily as the equation of lowest degree completely characterizes a dyadic when $n<4$. The treatment for $n=3$ is given in the first reference of p. 32): the treatment for $n=2$ may be regarded as a special case of that or as a special case of the investigation I gave in A generalized conception of area: applications to collineations in the plane--The Annals of Mathematics, second series, volume 5, pp. 29—45 (1903).

The ratios $x_1 : x_2 \ldots : x_n$ of these coordinates may be regarded as as homogeneous coordinates in a space of $n-1$ dimensions. In particular that space may be taken as the space at infinity in the original space of n dimensions. As the coefficients in (82) can be arbitrary, the transformation (82′) is the general projective transformation in $n-1$ dimensions. The correspondence between the two is not one to one: for all the equations in (82′) may be multiplied by a constant. In particular the constant may be so chosen that the determinant of (82′), which is supposed not to vanish, may be ± 1.[1] Thus the correspondence may be considered to be between unimodular strains and the collineations.

In this correspondence any projective reflection in the $(n-1)$-dimensional space at infinity becomes an oblique reflection of the types here considered by merely passing spaces through the fixed spaces of the projective reflection and through the origin, and conversely, any reflection in the spaces R_k, R_{n-k} of the n-dimensional space becomes a projective reflection in the plane at infinity and with the intersections of that plane and R_k, R_{n-k} as its fixed spaces. In the projective reflection the distinction between the reflections of types 0, n or 1, $n-1$ or 2, $n-2$ or ... entirely disappears: there is nothing corresponding to reversal of direction, as only the ratios of the coordinates are considered. Moreover the Hamilton-Cayley equation of the matrix of the coefficients in a projective transformation may be written

$$\Omega^n - \Omega_s\, \Omega^{n-1} + \Omega_{2s}\, \Omega_{n-2} - \ldots \pm \Omega_{n-2,\,s}\, \Omega^2 \mp \Omega_{n-1,\,s}\, \Omega \pm \Omega_n\, I = 0, \tag{83}$$

without any factors arising from the factor of proportionality which may effect the coordinates: for that factor enters into Ω_{ks} to the power k and into Ω_{n-k} to the power $n-k$, and hence may be canceled out. If the projective transformation may be resolved into the product of two projective reflections the equation for $\dfrac{\Omega}{\sqrt[n]{|\Omega_n|}}$ must be reciprocal and the invariant numbers corresponding to a pair of reciprocal roots of the scalar equation must be equal.

The connection with Smith's work already referred to is interesting. If a quadratic form in the n homogeneous variables in the plane at infinity is invariant, under any projective transformation of the variables, the same quadratic form must be invariant under

[1] The distinction between $+1$ and -1 may be disregarded except for questions of reality.

the corresponding strain. The interpretation of the form in this case gives a quadratic cone issuing from the origin and cutting the plane at infinity in the quadratic locus represented by the form in the n homogeneous variables. Smith has shown that any transformation with an invariant quadratic form may be resolved into two reflections. From this it is evident that the matrix of any such transformation must satisfy a reciprocal Hamilton-Cayley equation and that the invariant numbers corresponding to a pair of reciprocal roots must be equal. It may be noted that it is not true to say that any strain which leaves a quadratic cone issuing from the origin invariant is resoluble into two oblique reflections; it is necessary to add that the strain is unimodular or that the form which represents the cone is invariant.

The question naturally arises whether every projective transformation which is compounded of two reflections always has an invariant quadratric locus, that is, whether the conditions stated for resolubility into two reflections are both necessary and sufficient for a transformation with a non-degenerate quadratic form in n homogeneous variables. The answer is negative. To show whether any transformation resoluble into two reflection leaves a non-degerate quadric form invariant, it is merely necessary to examine the different cases that may arise. Consider the transformation written in the reduced form (76′). Let a and $\frac{1}{a}$ be a pair of roots corresponding to no shearing. As far as they are concerned the transformation may be written as

$$x' = a x_1,\ x'_2 = a x_2,\ \ldots,\ y'_1 = \frac{1}{a} y_1,\ y'_2 = \frac{1}{a} y_2,\ \ldots$$

and the quadratic terms

	x_1	x_2	...	y_1	y_2	...
x_1	0	0	0	1	0	0
x_2	0	0	0	0	1	0
...	0	0	0	0	0	1
y_1	1	0	0	0	0	0
y_2	0	1	0	0	0	0
...	0	0	1	0	0	0

of non-vanishing determinant are invariant. If there are shearing terms, the quadratic terms

	x_1	x_2	...	y_1	y_2	...
x_1	0	0	0	*	*	*
x_2	0	0	0	*	*	0
...	0	0	0	*	0	0
y_1	*	*	*	0	0	0
y_2	*	*	0	0	0	0
...	*	0	0	0	0	0

as seen above are invariant. If a root is $+1$ without shearing terms the invariant terms of the second degree are

	x_1	x_2	...
x_1	1	0	0
x_2	0	1	0
...	0	0	1

and the determinant does not vanish; and similarly in case of the root -1. If there are shearing terms corresponding to $+1$, the transformation may be written

$$x'_1 = x_1,\ x'_3 = x_2 + x_1,\ x'_3 = x_3 + x_2,\ \ldots,$$

and are invariant quadratic terms are

	x_1	x_2	x_3	...
x_1	1	$-\frac{1}{2}$	-1	0
x_2	$-\frac{1}{2}$	1	0	0
x_3	-1	0	0	0
...	0	0	0	0

The determinant vanishes if $n > 3$, and similarly for the case of a root -1. If these sets of quadratic terms corresponding to the various roots with or without shearing terms be arranged along the main diagonal of a matrix of order n, and if all the other spaces be filled with zeros, the result is a quadratic form in n variables which is invariant and which certainly has a non-vanishing determinant, unless $+1$ or -1 is a root with as many as three consecutive shearing terms.

It therefore appears that there are linear transformations in more than three variables which are compounded of two reflections and which leave no quadratic surface (with non-vanishing determinant) invariant. In other words, the converse of Smith's theorem is not always, although it is generally, true. The simplest example of the failure of the converse is in the collineations of three dimensions.

The collineation

(84) $\varrho\, x'_1 = x_1 + x_2,\ \varrho\, x'_2 = x_2 + x_3,\ \varrho\, x'_3 = x_3 + x_4,\ \varrho\, x'_4 = x_4,$

which corresponds to the strain

$$\Omega = \alpha\,\alpha' + \alpha\,\beta' + \beta\,\beta' + \beta\,\gamma' + \gamma\,\gamma' + \gamma\,\delta' + \delta\,\delta'$$

which has been factored into two reflections which in turn correspond to

T: $\varrho\, x'_1 = x_1 + x_2,\ \varrho\, x'_2 = -x_2,\qquad \varrho\, x'_3 = x_3 - x_4,\ \varrho\, x'_4 = x_4,$

S: $\varrho\, x'_1 = x_1,\ \varrho\, x'_2 = -x_2 + x_3 - x_4,\ \varrho\, x'_3 = x_3 - 2\,x_4,\ \varrho\, x'_4 = -x_4,$

leaves no non-degenerate quadratic surface $Q\ (x_1,\ x_2,\ x_3,\ x_4) = 0$ invariant. This is clearly seen from the analysis or from the following simple geometric reasoning. The collineation (84) has one and only one fixed plane p. This plane must be tangent to the quadric Q: for if it cut the quadric in a true conic, the conic being transformed into itself must have one fixed point, and the plane tangent to Q at this point would also be fixed. The fixed plane p, which is tangent to the conic quadric Q must intersect the quadric in two coincident straight lines or generators: for the collineation (84) cannot have two distinct fixed lines. But the only quadrics which can have a double line in common with a plane are the cones or other more degenerate quadrics. Hence the theory of collineations compounded of two reflections is not quite identical with the theory of collineations which leave invariant a non-degenerate quadric but includes it.

On the Resolution of Strains into Reflections.

17. *The product of a unimodular strain by the simplest reflection.* Consider a dyadic Ω where $\Omega_n = \pm 1$, and a reflection $I - 2\,\sigma|\bar{\sigma}$ of type 1 where the relation $\bar{\sigma}\,\sigma = 1$ holds. The scalar invariants $X_{2\,s},\ X_{3\,s},\ \ldots,\ X_{n-1,\,s}$ of the product

(85) $$X = \Omega\,(I - 2\,\sigma|\bar{\sigma}),$$

are determined by the expressions

(86) $$X_{k\,s} = [\Omega_k\,(I - 2\,\sigma|\bar{\sigma})_k\,]_s \qquad k = 2,\ 3,\ \ldots,\ n-1$$

If $(I - 2\,\sigma|\bar{\sigma})_k$ be expanded by the binomial theorem, there are only two terms in the expansions, namely,

(87) $$(I - 2\,\sigma|\bar{\sigma})_k = I_k - 2\,I_{k-1} \mathbin{\times\!\!\times} \sigma|\sigma.$$

Hence the scalar invariants take the form

(86′) $$\Omega_{k\,s} - 2\,(\Omega_k\,I_{k-1} \mathbin{\times\!\!\times} \sigma|\bar{\sigma})_{\,s} = \Omega_{k\,s} - 2\,\Omega_{k\,c} \mathbin{\times\!\!\times} (I_{k-1} \mathbin{\times\!\!\times} \sigma|\bar{\sigma})$$

It becomes necessary to investigate the expressions $\Omega_{k\,c} \mathbin{\times\!\!\times} (I_{k-1} \mathbin{\times\!\!\times} \sigma|\bar{\sigma})$ more in detail. It is clear that if the scalar quantity $\Omega_{k\,c} \mathbin{\times\!\!\times} (I_{k-1} \mathbin{\times\!\!\times} \sigma|\bar{\sigma})$

be expanded, each term of the expansion will contain a factor of the form $\bar{\sigma}\,\alpha$, a factor of the form $\bar{\beta}\,\sigma$, and no other factors which contains either σ or $\bar{\sigma}$. In other words, it will be possible to write

(88) $\Omega_k \overset{\times}{\times} (I_{k-1} \overset{\times}{\times} \sigma|\bar{\sigma}) = \Sigma\,(\bar{\sigma}\,\alpha)\ldots(\bar{\beta}\,\sigma) = \bar{\sigma}\,(\Sigma\,\alpha(..)|(..)\,\bar{\beta})\,\sigma = \bar{\sigma}\,\Xi^{(k)}\,\sigma$

where $\Xi^{(k)}$ is some dyadic with antecedents of one dimension and consequents of $n-1$ dimensions. The form of this dyadic will depend only on the dyadic Ω and not at all on its particular mode of representation. That is to say, the dyadics $\Xi^{(2)}$, $\Xi^{(3)}$, ..., $\Xi^{(n-1)}$ are invariant dyadics associated with Ω.

At first it will be best to treat $\Xi^{(2)}$. Let Ω be written as the sum

$$\Omega = \alpha'\bar{\alpha} + \beta|\bar{\beta} + \gamma|\bar{\gamma} + \ldots$$

of any number of dyads. Then Ω_2 will be of the form

$$\Omega_2 = \alpha\,\beta|\bar{\alpha}\,\bar{\beta} + \alpha\,\gamma|\bar{\alpha}\,\bar{\gamma} + \beta\,\gamma|\bar{\beta}\,\bar{\gamma} + \ldots$$

Let the idemfactor be $I = \lambda\lambda' + \mu\mu' + \nu\nu' + \ldots$, and consider the value of any term

(89) $$(\bar{\alpha}\,\bar{\beta}|\alpha\,\beta) \overset{\times}{\times} (\lambda\lambda' \overset{\times}{\times} \sigma|\bar{\sigma}) = (\bar{\alpha}\,\bar{\beta}\,\lambda\,\sigma)\,(\alpha\,\beta\,\lambda'\,\bar{\sigma})$$

A product like $\bar{\alpha}\,\bar{\beta}\,\lambda\,\sigma$ or $\alpha\,\beta\,\lambda'\,\bar{\sigma}$ is called a mixed product in distinction to the pure progressive or regressive products. The only formula which will be required here is

(90) $$\bar{\lambda}\,\bar{\mu}\,\bar{\nu}\ldots\alpha\,\beta\,\gamma\ldots = \begin{vmatrix} \bar{\lambda}\,\alpha & \bar{\mu}\,\alpha & \bar{\nu}\,\alpha & \ldots \\ \bar{\lambda}\,\beta & \bar{\mu}\,\beta & \bar{\nu}\,\beta & \ldots \\ \bar{\lambda}\,\gamma & \bar{\mu}\,\gamma & \bar{\nu}\,\gamma & \ldots \\ \ldots & \ldots & \ldots & \ldots \end{vmatrix}$$

which expresses the value of the scalar which results from multiplying any number (less than n) of vectors into the same number of spaces of $n-1$ dimensions.[1]

From the application of this formula to the case in hand there results

$$\begin{aligned}(\bar{\alpha}\,\bar{\beta}\,\lambda\,\sigma)(\bar{\lambda}\,\bar{\sigma}\,\alpha\,\beta) &= \begin{vmatrix} \bar{\alpha}\,\lambda & \bar{\alpha}\,\sigma \\ \bar{\beta}\,\lambda & \bar{\beta}\,\sigma \end{vmatrix} \cdot \begin{vmatrix} \lambda'\,\alpha & \lambda'\,\beta \\ \bar{\sigma}\,\alpha & \bar{\sigma}\,\beta \end{vmatrix} \\ &= (\alpha\,\lambda)\,(\lambda'\,\alpha)\,(\bar{\beta}\,\sigma)\,(\bar{\sigma}\,\beta) - (\bar{\alpha}\,\lambda)\,(\bar{\beta}\,\sigma)\,(\bar{\sigma}\,\alpha)\,(\lambda'\,\beta) \\ &\quad - (\bar{\beta}\,\lambda)\,(\bar{\alpha}\,\sigma)\,(\lambda'\,\alpha)\,(\bar{\sigma}\,\beta) + (\bar{\beta}\,\lambda)\,(\bar{\alpha}\,\sigma)\,(\bar{\sigma}\,\alpha)\,(\lambda'\,\beta) \\ &= \sigma\,[(\alpha\,\lambda\,\lambda'\,\alpha)\beta\,\bar{\beta} - (\bar{\alpha}\,\lambda\,\lambda'\beta)\alpha\,\bar{\beta} - (\bar{\beta}\,\lambda\,\lambda'\,\alpha)\beta\,\bar{\alpha} + (\bar{\beta}\,\lambda\,\lambda'\beta)\alpha\,\bar{\alpha}].\end{aligned}$$

There is a similar expression for the other terms $\mu\mu'$, $\nu\nu'$, ... of I. These may then be added together and simplified by the relations $\bar{\alpha}\,I\,\alpha = \bar{\alpha}\,\alpha$ and so forth. The result is that the contribution of $\alpha\,\beta|\bar{\alpha}\,\bar{\beta}$ to $\Xi^{(2)}$ is

$$(\bar{\alpha}\,\alpha)\,\beta|\bar{\beta} - (\bar{\alpha}\,\beta)\,\alpha|\bar{\beta} - (\bar{\beta}\,\alpha)\,\beta|\bar{\alpha} + (\bar{\beta}\,\beta)\,\alpha|\bar{\alpha}.$$

Hence finally

[1] See footnote to p. 9.

(91) $\Xi^{(2)} = \Sigma\,[(\bar\beta\,\beta)\,\alpha|\bar\alpha + (\bar\alpha\,\alpha)\,\beta|\bar\beta - (\bar\alpha\,\beta)\,\alpha|\bar\beta - (\bar\alpha\,\beta)\,\beta|\bar\alpha],$

where the summation covers all pairs of antecedents $\alpha,\ \beta,\ \gamma,\ \ldots$ of Ω. The form of this expression evidently bears out the statement that the expression is independent of the manner in which Ω is written: for if α is replaced by $\alpha_1 + \alpha_2$, the sum of the terms due to $\alpha_1\beta|\bar\alpha\bar\beta$ and $\alpha_2\beta|\bar\alpha\bar\beta$ is the same as those due to $\alpha\beta|\bar\alpha\bar\beta$, and so is it for similar changes in any of the elements that enter into Ω.

To pass on to $\Xi^{(3)}$ consider the typical product

$$(\bar\alpha\,\bar\beta\,\bar\gamma\ \lambda\,\mu\,\sigma)\ (\lambda'\,\mu'\,\bar\sigma\ \alpha\,\beta\,\gamma) = \bar\sigma \begin{vmatrix} \gamma' & \alpha & \mu' & \alpha & \alpha \\ \gamma' & \beta & \mu' & \beta & \beta \\ \lambda' & \gamma & \mu' & \gamma & \gamma \end{vmatrix} \begin{vmatrix} \bar\alpha & \gamma & \bar\alpha & \mu & \bar\alpha \\ \bar\beta & \lambda & \bar\beta & \mu & \bar\beta \\ \bar\gamma & \lambda & \bar\gamma & \mu & \bar\gamma \end{vmatrix} \sigma$$

The coefficient of the dyad $\alpha|\bar\alpha$ is

$$\begin{vmatrix} \lambda' & \beta & \mu' & \beta \\ \lambda' & \gamma & \mu' & \gamma \end{vmatrix} \begin{vmatrix} \bar\beta & \lambda & \bar\beta & \mu \\ \bar\gamma & \lambda & \bar\gamma & \mu \end{vmatrix} = (\bar\beta\,\bar\gamma\ \lambda\,\mu)\ (\lambda'\,\mu'\,\beta\,\gamma) = \bar\beta\,\gamma\,(\lambda\mu|\lambda'\mu')\,\beta\gamma.$$

If this be summed over all pairs of different antecedents of I, the result is the term $(\bar\beta\,\bar\gamma\,\beta\,\gamma)\ \alpha|\bar\alpha$ of $\Xi^{(3)}$. In like manner the coefficients of $\alpha|\bar\beta$, $\alpha|\bar\gamma$, $\beta|\bar\gamma$, ... may be found. In fact the rule for writing down the desired term is merely to pick out the two elements from the set $\bar\alpha\bar\beta\bar\gamma\alpha\beta\gamma$, leaving the other four to form the scalar coefficients with the proper sign (which may be determined according to the rule for expanding the determinants above) — thus

$$-(\bar\alpha\,\bar\gamma\ \alpha\,\beta)\ \gamma'|\bar\beta, \qquad +(\alpha\,\beta\ \alpha\,\beta)\ \gamma'|\bar\gamma, \qquad -(\bar\beta\,\bar\gamma\ \alpha\,\gamma)\ \beta'|\bar\alpha.$$

The extension to $\Xi^{(k)}$ is now immediate. There is no need of going into the details.

If Ω is expressed in matricular form as

$$\Omega = \Sigma\, a_{ij}\ \alpha_i|\alpha'_j,\ \ \Omega_2 = \tfrac{1}{2}\,\Sigma\, a_{ij}\ a_{lm}\ \alpha_i\,\alpha_l|\alpha'_j\,\lambda'_m,\ \ \ldots$$

it is possible to calculate $\Xi^{(2)}$, $\Xi^{(3)}$, ... also in matricular form. From (9)

$$\begin{aligned}\Xi^{(2)} &= \tfrac{1}{2}\,\Sigma\, a_{ij}\ a_{lm}\,[(\alpha'_m\,\alpha_l)\ \alpha_i|\alpha'_j + (\alpha'_j\,\alpha_i)\ \alpha_l|\alpha'_m - (\alpha'_j\,\alpha_l)\ \alpha_i|\alpha'_m \\ &\qquad - (\alpha'_m\,\alpha_i)\ \alpha_l|\alpha'_j] \\ &= \Sigma\, a_{ij}\ a_{lm}\,(\alpha'_m\,\alpha_l)\ \alpha_i|\alpha'_j - \Sigma\, a_{ij}\,a_{lm}\,(\alpha'_j\,\alpha_l)\ \alpha_i|\alpha'_m\end{aligned}$$

It should be noted that $i \neq l$ and $j \neq m$, and that terms in the first sum vanish unless $l = m$, in which case $\alpha'_m\ \alpha_l = 1$; and similarly in the second sum $j = l$. Hence the coefficient of any dyad $\alpha_i|\alpha'_j$ in $\Xi^{(2)}$ is

$$\Big(a_{ij}\,\Sigma'_l\ a_{l\,l} - \Sigma'_l\ a_{i\,l}\,a_{l\,j}\Big)\ \alpha_i|\alpha'_j$$

where the accent on the Σ indicates that those terms for which the variable index is equal to either of the fixed indices are to be omitted. These sums may be written in the form

(91′) $$\Xi^{(2)} = \sum_{i,j}\ \Sigma'_l \begin{vmatrix} a_{ij} & a_{il} \\ a_{lj} & a_{ll} \end{vmatrix} \alpha_i|\alpha'_j, \quad (l-i)\ (l-j) \neq 0.$$

Analogously to (91) the formula for $\Xi^{(3)}$ is

$$\Xi^{(3)} = \Sigma\,[(\bar\beta\,\bar\gamma\,\beta\,\gamma)\,\alpha|\bar\alpha + (\bar\alpha\,\bar\gamma\,\alpha\,\gamma)\,\beta|\bar\beta + (\bar\alpha\,\bar\beta\,\alpha\,\beta)\,\gamma|\bar\gamma - (\bar\alpha\,\bar\gamma\,\beta\,\gamma)\,\alpha|\bar\beta + (\bar\alpha\,\bar\beta\,\beta\,\gamma)\,\alpha|\bar\gamma + (\bar\beta\,\bar\gamma\,\alpha\,\gamma)\,\beta|\bar\alpha - (\bar\alpha\,\bar\beta\,\alpha\,\gamma)\,\beta|\bar\gamma + (\bar\beta\,\bar\gamma\,\alpha\,\beta)\,\gamma|\bar\alpha - (\bar\alpha\,\bar\gamma\,\alpha\,\beta)\,\gamma|\bar\beta]. \tag{92}$$

And

$$\Omega_3 = \frac{1}{6}\,\Sigma\, a_{ij}\,a_{lm}\,a_{pq}\,\alpha_i\,\alpha_l\,\alpha_p|\,\alpha_j\,\alpha'_m\,\alpha'_q, \qquad \begin{matrix} i,l,p \text{ all unequal} \\ j,m,q \text{ all unequal} \end{matrix}$$

After making the necessary substitutions and reductions, it appears that

$$\Xi^{(3)} = \sum_{i,j}\ \sum_{l,m}{}'' \begin{vmatrix} a_{ij} & a_{il} & a_{im} \\ a_{lj} & a_{ll} & a_{lm} \\ a_{mj} & a_{ml} & a_{mm} \end{vmatrix} \alpha_i|\,\alpha'_j \tag{92'}$$

where the double accent on Σ means that l and m cannot be equal among themselves nor equal to i or j. Moreover the equal results obtained from $l=a$, $m=b$ and from $l=b$, $m=a$ have been accounted for. The formula for $\Xi^{(k)}$ is the obvious generalisation of the results for $\Xi^{(2)}$ and $\Xi^{(3)}$. The result for $\Xi^{(k)}$ may be stated in words: To find the coefficients of $\alpha_i|\,\alpha'_j$ in $\Xi^{(k)}$, form a determinant of the kth order from the matrix of Ω by taking as the main diagonal a_{ij} and any combination (not permutation) of $k-1$ of the elements in the main diagonal of Ω excluding a_{ii}, a_{jj} and add the determinants of all possible combinations.

With the aid of these dyadics it is possible to express the invariants of the product of a dyadic and $I-2\,\sigma|\bar\sigma$. Let

$$X = \Omega\,(I-2\,\sigma|\bar\sigma) \tag{85}$$

Then

$$X_s = \Omega_s - 2\,\bar\sigma\,\Omega\,\sigma,\quad X_{ks} = \Omega_{ks} - 2\,\bar\sigma\,\Xi^{(k)}\,\sigma,\quad k=2,3,\ldots,n-1, \tag{93}$$
$$X_n = -\,\Omega_n$$

A similar result could be obtained for the product

$$X' = \Omega\,(I-2\,\sigma|\bar\sigma - 2\,\tau|\bar\tau) \tag{94}$$

Here however, the expansion by the binomial theorem is

$$(I-2\,\sigma\,\bar\sigma-2\,\tau\,\bar\tau)_k = I_k - 2\,I_{k-1}\,(\sigma\,\bar\sigma+\tau\,\bar\tau) + 4\,I_{k-2}\,[\sigma\tau|\bar\sigma\bar\tau];$$

and hence

$$X'_{ks} = \Omega_{ks} - 2\,\bar\sigma\,\Xi^{(k)}\,\sigma - 2\,\bar\tau\,\Xi^{(k)}\,\tau + 4\,\Omega_{ks}\times(I_{k-2}\times\sigma\tau|\bar\sigma\bar\tau) \tag{94'}$$

The term $\Omega_{kc}\times(I_{k-2}\times\sigma\tau|\bar\sigma\bar\tau)$ could be treated as $\Omega_{kc}\times(I_{k-1}\times\sigma|\bar\tau)$ was treated; and the invariant dyadic which resulted would be of the second type, that is, the antecedents would be of the form $\alpha\,\beta$ and the consequents of the form $\bar\alpha\,\bar\beta$. In like manner for products with more complex square roots of I, would yield invariant dyadics of higher types. The study of these dyadics will not be taken up at this time.

The converse problem is interesting, namely, given a dyadic Ω, to find what dyadics may result from the product $\Omega\,(I-2\,\sigma|\bar{\sigma})$ by a suitable choice of the reflection $I-2\,\sigma|\bar{\sigma}$. Consider the scalar invariants of the product. The determinant of the product must be the negative of Ω_n. Suppose it be desired to make the other scalar invariants take assigned arbitrary values. This amounts to the solution of the equations

$$(96)\quad \begin{array}{l} \bar{\sigma}\,\Omega\,\sigma = l \\ \bar{\sigma}\,\Xi^{(2)}\sigma = m \\ \bar{\sigma}\,\Xi^{(3)}\sigma \quad p \\ \cdots\cdots \end{array} \quad \text{or} \quad \begin{array}{l} \bar{\sigma}\,(\Omega - l\,I)\,\sigma = 0 \\ \bar{\sigma}\,(\Xi^{(2)} - m\,I)\,\sigma = 0 \\ \bar{\sigma}\,(\Xi^{(3)} - p\,I)\,\sigma \quad 0 \\ \cdots\cdots\cdots \end{array} \quad n-1 \text{ equations}$$

under the condition $\bar{\sigma}\,\sigma \neq 0$. In other words it amounts to finding a space $\bar{\sigma}$ which shall contain $(\Omega - l\,I)\,\sigma$, $(\Xi^{(2)} - m\,I)\,\sigma$, . . . but not contain σ. Suppose the roots of Ω are distinct and for simplicity let $n=4$. Then

$$\Omega = a\,\alpha|\alpha' + b\,\beta|\beta' + c\,\gamma|\gamma' + d\,\delta|\delta'$$

$$(96)\quad \begin{aligned} \Xi^{(2)} = {} & a(b+c+d)\,\alpha|\alpha' + b\,(c+d+a)\,\beta|\beta' + c\,(d+a+b)\,\gamma|\gamma' \\ & + d\,(a+b+c)\,\delta|\delta' \\ \Xi^{(3)} = {} & a(bc+bd+cd)\,\alpha|\alpha' + b\,(cd+ca+da)\,\beta|\beta' \\ & + c\,(da+db+ab)\,\gamma|\gamma' + d\,(ab+ac+bc)\,\delta|\delta' \\ \sigma = {} & x\,\alpha + y\beta + y\gamma + w\,\delta \end{aligned}$$

The three vectors $(\Omega - l\,I)\,\sigma$, $(\Xi^{(2)} - m\,I)\,\sigma$, $(\Xi^{(3)} - p\,I)\,\sigma$ are easily written down and the desired $\bar{\sigma}$ may be passed through them unless the condition

$$(97)\quad \begin{vmatrix} (a-l)\,x & [a(b+c+d)-m]\,x & [a(bc+bd+cd)-p]\,x & x \\ (b-l)\,y & [b(c+d+a)-m]\,y & [b(cd+ca+da)-p]\,y & y \\ (c-l)\,z & [c(d+a+b)-m]\,z & [c(da+db+ab)-p]\,z & z \\ (d-l)\,w & [d(a+b+c)-m]\,w & [d(ab+ac+bc)-p]\,w & w \end{vmatrix} = 0$$

which expresses the fact that they lie in a 3-dimensional space with σ, holds. This may be reduced to the simpler form

$$(97')\quad \begin{vmatrix} a & a(b+c+d) & a(bc+bd+cd) & 1 \\ b & b(c+b+a) & b(cd+ca+da) & 1 \\ c & c(d+a+b) & c(da+db+ab) & 1 \\ d & d(a+b+c) & d(ab+ac+bc) & 1 \end{vmatrix} \equiv P_6\,(a,b,c,d) = 0$$

This is a polynomial of degree 6 in a, b, c, d. It is obvious that the polynomial will vanish if any two of the roots are equal. Hence

$$(97'')\quad P_6\,(a,b,c,d) = k\,(a-b)\,(a-c)\,(a-d)\,(b-c)\,(b-d)\,(c-d),$$

and according to the supposition that the roots are distinct $P_6 \neq 0$.

From this it follows that if the roots of Ω are distinct, a reflection, $I-2\,\sigma|\bar{\sigma}$ of type I may be found which will make the product $\Omega\,(I-2\,\sigma|\bar{\sigma})$ take such a form as to have any desired scalar invariants, with the exception of the determinant which is $-\Omega_n$

Moreover it appears that the choice of σ is arbitrary except that it shall not lie in any of the invariant spaces of $n-1$ dimensions. The result is stated for n dimensions because the proof is the same as for four. In particular these scalar invariants may be chosen so as to make the Hamilton-Cayley equation of the product a reciprocal equation with distinct roots, and hence the product is resoluble into two reflections. Geometrically this means that a reflection of the first type may be found in ∞^{n-1} ways such that the product of the reflection and any collineation (or any unimodular proper or improper strain) which has distinct roots is resoluble into two reflections. In other words, Ω in this case is always resoluble into three reflections, or analytically may be regarded as the product of three square roots of the idemfactor.

18. *Some special cases of the product.*—The theorem which has just been established for the general case where the roots of Ω are distinct may be extended. It is clear that Ω may be such that the product $\Omega\,(I-2\,\sigma|\bar{\sigma})$ cannot have arbitrary scalar invariants: for if Ω were a reflection the product would have to have such invariants as to make a reciprocal equation. It may, however, be shown that: If the Hamilton-Cayley equation of a dyadic Ω is the equation of lowest degree, the choice of a reflection $I-2\,\sigma|\bar{\sigma}$ may be made in ∞^{n-1} ways so that the scalar invariants of the product $\Omega\,(I-2\,\sigma|\bar{\sigma})$ are arbitrary with the exception of the determinant which is $-\Omega_n$. It should be noted that the condition that the Hamilton-Cayley equation be identical with the equation of lowest degree is equivalent to saying that in the canonical form (64) to which the dyadic may be reduced all the shearing terms corresponding to equal roots must be present. If $n=4$ the possible cases are

(98)
$$\Omega = a\,\alpha\alpha' + a\,\beta\beta' + c\,\gamma\gamma' + d\,\delta\delta' + \alpha\beta'$$
$$\Omega = a\,\alpha\alpha' + a\,\beta\beta' + a\,\gamma\gamma' + d\,\delta\delta' + \alpha\beta' + \beta\gamma'$$
$$\Omega = a\,\alpha\alpha' + a\,\beta\beta' + a\,\gamma\gamma' + a\,\delta\delta' + \alpha\beta' + \beta\gamma' + \gamma\delta'$$
$$\Omega = a\,\alpha\alpha' + a\,\beta\beta' + c\,\gamma\gamma' + c\,\delta\delta' + \alpha\beta' + \gamma\delta'$$

(The vertical bar has been omitted for brevity.)

As the proof of theorem in general involves great detail, and at the same time general reasoning on tolerably varied and involved formulas, it will be well to carry the computation through in these cases, after which the general cases will offer no particular difficulty. The expressions for $\Xi^{(2)}$ and $\Xi^{(3)}$ in each of the cases above are

(98′) $\Xi^{(2)} = a(a+c+d)\alpha\alpha' + a(a+c+d)\beta\beta' + (c+d)\alpha\beta' + c(a+a+d)\gamma\gamma' + d(a+a+c)\delta\delta'$

$\Xi^{(3)} = a(ac+ad+cd)\alpha\alpha' + a(ac+ad+cd)\beta\beta' + cd\alpha\beta' + c(ad+ad+aa)\gamma\gamma' + d(ac+ac+aa)\delta\delta'$

$\Xi^{(2)} a(2a+d)\alpha\alpha' + a(2a+d)\beta\beta' + (a+d)\alpha\beta' + a(2a+d)\gamma\gamma' + (a+d)\beta\gamma' - 1\alpha\gamma' + d(2a+a)\delta\delta'$

$\Xi^{(3)} = a(a^2+2ad)\alpha\alpha' + a(a^2+2ad)\beta\beta' + ad\alpha\beta' + a(a^2+2ad)\gamma\gamma' + ad\beta\gamma' - d\alpha\gamma' + d(a^2+2a^2)\delta\delta'$

$\Xi^{(2)} = a(3a)\alpha\alpha' + a(3a)\beta\beta' + 2a\alpha\beta' + a(3a)\gamma\gamma' + 2a\beta\gamma' - \alpha\gamma' + a(3a)\delta\delta' + 2a\gamma\delta' - \beta\delta'$

$\Xi^{(3)} = a(3a^2)\alpha\alpha' + a(3a^2)\beta\beta' + a^2\alpha\beta' + a(3a^2)\gamma\gamma' + a^2\beta\gamma' - a\alpha\gamma' + a(3a^2)\delta\delta' + a^2\gamma\delta' - a\gamma\delta' + a\alpha\delta'$

$\Xi^{(2)} = a(a+2c)\alpha\alpha' + a(a+2c)\beta\beta' + 2c\alpha\beta' + c(c+2a)\gamma\gamma' + c(c+2a)\delta\delta' + 2a\gamma\delta'$

$\Xi^{(3)} = a(2ac+c^2)\alpha\alpha' + a(2ac+c^2)\beta\beta' + c^2\alpha\beta' + c(2ac+a^2)\gamma\gamma' + c(2ac+a^2)\delta\delta' + a^2\gamma\delta'$

In the first case the condition that the solution desired be impossible is

(99)
$$\begin{vmatrix} (a-l)x+y & [a(a+c+d)-m]x+(c+d)y & [a(ac+ad+cd)-p]x+cdy & x \\ (a-l)y & [a(a+c+d)-m]y & [a(ac+ad+cd)-p]y & y \\ (c-l)z & [c(a+a+d)-m]z & [c(ad+ad+aa)-p]z & z \\ (d-l)w & [d(a+a+c)-m]w & [d(ac+ac+aa)-p]w & w \end{vmatrix} = 0$$

Here the last column may be multiplied by l, m, p, and subtracted from the first, second, third columns respectively, and thus the l, m, p disappear; the w, z, y of the last three lines may be canceled out; the second line may be multiplied by x and substracted from the first and then the y in that line disappears. Finally the second line may be subtracted from each of the last two. The condition reduces to

(99′)
$$\begin{vmatrix} 1 & c+d & cd & 0 \\ a & a(a+c+d) & a(ac+ad+cd) & 1 \\ c-a & (c-a)(a+d) & (c-a)ad & 0 \\ d-a & (d-a)(a+c) & (d-a)cd & 0 \end{vmatrix} = 0.$$

Here it still is clear that even if the factors $c-a$ and $d-a$ are stricken out the expression will vanish if a equals c or d or if c and d are equal. As the expression is only of degree five, it must be of the form

(99″) $$P_5(a, c, d) \equiv k(c-a)^2(d-a)^2(c-d).$$

Hence P_5 does not vanish unless two of the roots a, c, d are equal.

The second case is between the first and third. In this case it turns out that the polynomial to which the determinant reduces is

$$P_3(a, d) \equiv k(d-a)^3$$

and cannot vanish unless a and d are equal. In the third case the determinant is

$$(100)\quad \begin{vmatrix} ax+y & 3a^2x+2ay-z & 3a^3x+a^2y-az+w & x \\ ax+z & 3a^2y+2az-w & 3a^3y+a^2z-aw & y \\ az+w & 3a^2z+2aw & 3a^3z+a^2w & z \\ aw & 3aw & 3a^3w & w \end{vmatrix} = 0,$$

where the l, m, p have been omitted as they obviously go out by the same reasoning as before. Here the w factors out of the last row, which may then be multiplied by x, y, z and subtracted respectively from the first, second, third rows. The w then factors out of the third row, which may be multiplied by y, z and subtracted from the rows above. Now the factor w drops out of the second row, which may be multiplied by z and subtracted from the top row whereupon the y drops out. The condition is reduced to

$$(100')\quad \begin{vmatrix} 0 & 0 & 1 & 0 \\ 0 & -1 & -a & 0 \\ 1 & 2a & a^2 & 0 \\ a & 3a^2 & 3a^3 & 1 \end{vmatrix} = 1 = 0,$$

which is clearly unfulfilled.

The last case is instructive, because it illustrates the dependence and independence of different repeated roots. The condition is

$$(101)\quad \begin{vmatrix} ax+y & a(a+2c)x-c^2y & a(2ac+c^2)x+c^2y & x \\ ay & a(a+2c)y & a(2ac+c^2)y & y \\ cx+w & c(c+2a)z+a^2w & c(2ac+a^2)z+a^2w & z \\ cw & c(c+2a)w & c(2ac+a^2)w & w \end{vmatrix} = 0$$

The y, w of the second and third lines go out, and a reduction similar to that given before removes the x, z. It is this possibility to get rid of the coefficients in the expression for σ, which shows that these coefficients may have any values other than 0. The condition reduces to

$$(101')\quad \begin{vmatrix} 1 & -2c & c^2 & 0 \\ a & a(a+2c) & a(2ac+c^2) & 1 \\ 1 & -2a & a^2 & 0 \\ c & c(c+2a) & c(2ac+a^2) & 1 \end{vmatrix} = 0$$

which amounts to merely

$$(101'')\quad P_4(a, c) \equiv k(a-c)^4$$

and cannot vanish.

The foregoing cases are typical of all that can arise. With regard to the case where n has any value the following remarks will suffice. Suppose that Ω has k repeated roots a. Construct the half square upon the portion of the main diagonal of Ω correspond-

ing to these roots. The shearing terms will be $k-1$ in number and will be situated in the next diagonal line. In constructing $\Xi^{(2)}$ there will be shearing terms in the corresponding line. Moreover the next diagonal line will contain terms to the full number $k-2$: but there will be no other terms in the half square. In construction $\Xi^{(3)}$ there will be terms in these two lines and also in the line third removed from the main diagonal. And so on until $\Xi^{(k-1)}$ has a term in the corner of the half-square. Such is the case for every set of repeated roots. All the other terms will be lacking in $\Xi^{(2)}$, $\Xi^{(3)}$, ... These results are all obvious consequences of the determinantal definition of the coefficients in $\Xi^{(2)}$, $\Xi^{(3)}$, ... The determinant which must not vanish if the solution of the problem is possible will reduce to the discriminant of the roots of Ω, where however the differences which correspond to repetitions of the same root have disappeared. This is the only change: for the differences which correspond to different repeated roots occur as many times as the product of the multiplicities of those roots.

The proof of these general theorems is carried out by mathematical induction. It is merely necessary to show that, on the assumption that the results are true for any given distribution of roots, they still remain true when the number of roots and the number of dimensions is increased by one, whether by adding a root equal to one already existing or different from all those present. In any given case the proof is very simple; but on the assumption that there are k roots of multiplicities $m_1, m_2, \ldots, m_k$ the notation becomes very cumbersome. As there is no other difficulty than this, it seems hardly worth while to insert the general proof at this point. The geometrical consequences of the theorem of this article are: That any collineation or strain of which the Hamilton-Cayley equation is the equation of lowest degree may be converted by multiplication with a reflection $1-\sigma|\bar{\sigma}$, which may be chosen in ∞^{n-1} ways, into a collineation or strain which has roots arbitrary except that their product must be the negative of the product of the roots of the given collineation or strain. In particular these roots may be chosen in such a way that the resulting collineation or (unimodular) strain may be resolved into two reflections.

19. *On the product of a strain and a reflection.*—Although it is evident that no reflection of type 1, nor any reflection of any type can be found which will make the scalar invariants of the product of any given unimodular strain and that reflection arbitrary, and

that therefore the method adopted in the last two articles for showing that such a strain may be resolved into three reflections must break down in some of the special cases (for instance when the given strain is itself a reflection), the theorem that any strain is resoluble into three properly chosen reflections is strongly suggested. If Ω be a strain and Φ a reflection, the necessary and sufficient condition that $\Omega\Phi$ be resoluble into two reflections is seen from article 15 to be that the Hamilton-Cayley equation of $\Omega\Phi$ shall be reciprocal, and that the invariant numbers which correspond to a pair of reciprocal roots of the scalar equation shall be equal. The first part of this condition is not hard to state and, in the simplest cases, to examine. The last part of the condition apparently requires very detailed consideration.

For the present purposes the fourfold division of the problem, according as n is odd or even and Ω_n is $+1$ or -1, may be somewhat abridged by the use of (70). If $X=\Omega\Phi$, the conditions become

$$X_{ks}=X^{-1}_{ks}, \quad k<E\left(\tfrac{n}{2}\right), \quad X_{\frac{n}{2}s}=0 \tag{102}$$

with the supplementary condition necessary only when n is even and the determinant of the product $X_n=-1$, and with the further condition that the invariant numbers which correspond to any pair of reciprocal roots of X must be equal. These are the necessary and sufficient conditions that Ω be resoluble into three reflections. In case Φ happens to be of type 1, these conditions reduce to

$$\sigma[\Omega-\Omega^{-1}-\tfrac{1}{2}(\Omega_s-\Omega_s^{-1})I]=0, \tag{102'}$$

$$\sigma[\Xi^{(k)}-\Xi^{(-k)}-\tfrac{1}{2}(\Omega_{ks}-\Omega_{ks}^{-1})I]\sigma=0, \quad 1<k<E\left(\tfrac{n}{2}\right),$$

and if n is even and $X_n=-1$, $\bar{\sigma}[\Xi^{\left(\frac{n}{2}\right)}-\tfrac{1}{2}\Omega_{\frac{n}{2}s}I]\sigma=0$,

where $\Xi^{(-k)}$ has been written as an abbreviation for the kth invariant dyadic Ξ associated with Ω^{-1}. Thus there are $E\left(\frac{n}{2}\right)$ equations to be satisfied in case n is odd, or in case n is even and $X_n=-1$; but if n is even and $X_n=+1$ there are only $E\left(\frac{n}{2}\right)-1$ equations to be fulfilled. In all cases they must be satisfied subject to the restriction $\sigma\sigma=|=0$. If Φ were of type 2, or higher up to type $E\left(\frac{n}{2}\right)$, the conditions which would be analogous to (102′) might be expressed in terms of the invariant dyadics of higher class referred to in article 17 but not investigated.

The connection of the conditions (102′) with work which has already been accomplished is this. In case $n=2$, the only reflection is of type 1 and if $\Omega_n=-1$, $X_n=+1$, there is no condition to be fulfilled. Hence the transformation Ω may always be written as the product of three reflections. If $\Omega_n=+1$, the Hamilton-Cayley equation of Ω is necessarily reciprocal and Ω is resoluble into two reflections. These results are well known; and as far as collineations are concerned there is no distinction between the two cases except as regards reality. If $n=3$, there is only the one reflection, which is of type one, (except for its negative) and only one condition — which may always be satisfied.[1] Hence in three dimensions the resolution into three reflections is always possible. In case $n=4$ and Φ is of type 1 and $\Omega_n=-1$, there is still only one condition (102′) to be satisfied, and it can clearly be satisfied: but another difficulty arises owing to the fact that if a, $\frac{1}{a}$ are double roots of the product X, it may conceivably arise that for all reflections Φ which satisfy the condition there may be a shearing term for one of the roots and none for the other, so that the supplementary condition concerning the invariant numbers would not be fulfilled. In a delicate question of this sort a count of constants is of no value; a detailed investigation of the product X is required. Whereas if $\Omega_n=+1$, there are two conditions (102′) to be satisfied simultaneously, and in view of the developments of article 47 it is by no means evident that this may always be accomplished. If Φ is of type 2 and $\Omega_n=-1$, there are again two conditions (102) to satisfy, not to mention the conditions imposed by the invariant numbers, and again it is not obvious that they can be met. If however $\Omega_n=+1$, Smith's theorem previously cited, and arising out of the special fact that a collineation in four homogeneous variables may be regarded as a collineation in six variables with an invariant quadratic form, may be adduced to show that all the conditions (102) may be satisfied. If $n>4$, the difficulties signalised for the first three cases when $n=4$, are further emphasized.

To show that these difficulties are not only conceivable but actually arise, it is worth while to treat the simplest case. Suppose (103) $\Omega=a\,\alpha|\alpha'+a\,\beta|\beta'+a\,\gamma|\gamma'+a^{-3}\delta|\delta'$, $\Omega_n=+1$, $\Phi=I-2\,\bar{\sigma}|\sigma$ Here there are two conditions so satisfy, namely

(104) $\bar{\sigma}[\Omega-\Omega^{-1}-\frac{1}{2}(\Omega_s-\Omega_s^{-1})I]\,\sigma=0$, $\bar{\sigma}[\Xi^{(2)}-\frac{1}{2}\Omega_{2\,s}I]\,\sigma=0$.

[1] This is precisely the condition of my theorem 23, p. 295, of my communication to the Transactions cited in the footnote on page 32.

As Φ possesses six degrees of freedom, a count of constants would indicate that the two conditions could be satisfied. The actual computation is conducted as follows.[1]

$$\Omega^{-1} = a^{-1}\,\alpha|\alpha' + a^{-1}\,\beta|\beta' + a\,\gamma|\gamma' + a^3\,\delta|\delta'$$

$$\Omega_s = 3\,a + a^{-3},\ \Omega_s^{-1} = 3\,a^{-1} + a^3,\ \Omega_{2\,s} = \Omega_{2\,s}^{-1} = 3a^2 + 3\,a^{-2},$$

$$\Xi^{(2)} = a\,(2a + a^{-3})\,\alpha|\alpha' + a\,(2a + a^{-3})\,\beta|\beta' + a\,(2a + a^{-3})\,\gamma|\gamma' + 3a^{-2}\,\delta|\delta',$$

$$\Xi^{(2)} - \tfrac{1}{2}\,\Omega_{2\,s}\,I = \tfrac{1}{2}\,(a^2 - a^{-2})\,[\alpha|\alpha' + \beta|\beta + \gamma|\gamma' - 3\,\delta|\delta']$$

$$\Omega - \Omega^{-1} - \tfrac{1}{2}\,(\Omega_s - \Omega_s^{-1})\,I = \tfrac{1}{2}\,(a - a^{-1})\,[(a + a^{-1})^2\,(\alpha|\alpha' + \beta|\beta' + \gamma|\gamma') - (a^2 + 4 + a^{-2})\,\delta|\delta']$$

From these expressions, it is found that $[\Omega - \Omega^{-1} - \tfrac{1}{2}\,(\Omega_s - \Omega_s^{-1})\,I]\,\sigma$ and $[\Xi^{(2)} - \tfrac{1}{2}\,\Omega_{2\,s}\,I]\sigma$ are $\tfrac{1}{2}\,(a - a^{-1})\ [A\,x\,\alpha + A\,y\,\beta + A\,z\,\gamma - A'w\,\delta)$ and $\tfrac{1}{2}\,(a^2 - a^{-2})\ [x\,\alpha + y\,\beta + z\,\gamma - 3\,w\,\delta]$

where $A = (a + a^{-1})^2$, $A' = a^2 + 4 + a^{-2}$, $\sigma = x\,\alpha + y\,\beta + z\,\gamma + w\,\delta$. Neither of these vectors vanishes identically unless $a - a^{-1} = 0$ or $a^2 - a^{-2} = 0$, that is, unless a is a square root or fourth root of unity. From the form of the vectors it is clear that they cannot be collinear unless

$$\begin{vmatrix} A & A' \\ 1 & 3 \end{vmatrix} = \begin{vmatrix} a^2 + 2\,a^{-2} & a^2 + 4 + a^{-2} \\ 1 & 3 \end{vmatrix} = 2\,(a^2 + 1 + a^{-2}) = 0 \text{ or } w = 0.$$

In the first case a must be a sixth root of unity, and in the second the two vectors are both parallel to σ. As the constant a in Ω may be arbitrary, the first case can be excluded, and the second violates the condition $\bar{\sigma}\,\sigma \neq 0$. Hence it may be assumed that the two vectors are independent and determine a plane through which any $\bar{\sigma}$ must pass. But this plane clearly contains σ inasmuch as any three rowed determinant from the matrix

$$\begin{Vmatrix} Ax & Ay & Az & A'w \\ x & y & z & 3\,w \\ x & y & z & w \end{Vmatrix}$$

vanishes. Hence again the condition $\bar{\sigma}\,\sigma \neq 0$ is violated, and it is evident that despite the six degrees of freedom, no reflection $\Phi = I - 2\,\bar{\sigma}|\sigma$ can be chosen such that the conditions (104) may be fulfilled, and $\Omega\,\Phi$ may (possibly) be resoluble with two reflections. It is necessary to try a different type of reflection. As a matter of fact Smith's theorem happens to be applicable to this particular case.

The detailed discussion of the various difficulties which arise in the different special cases must be postponed to a later time. There is one question which will be suggested and left as an easy exercise in the use of the dyadics Ξ. It is geometrically apparent that, if

[1] It may be noted that in the fourth line down $X_{2\,s}^{-1} = \Xi^{(2)} - \tfrac{1}{2}\,\Omega_{2\,s}^{-1}\,I$ would be the negative of the given value as it should be.

Ω is itself resoluble into two reflections, then it must be possible to find a reflection Φ of type 1 such that the product $\Omega\Phi$ is still resoluble into two reflections, and consequently the conditions (102') must be capable of fulfilment in this case.

The results of the second part of this paper may be summarised as follows:

1°. The determination of the square roots of the idemfactor by means of the properties of the equation of least degree.

2°. The determination of the necessary and sufficient conditions that a dyadic be resoluble into the product of two square roots of the idemfactor.

3°. The correlation of these results with the theory of reflections in connection with unimodular strains and with collineations. And in particular, the fact that not all products of two reflections leave a non-degenerate quadric invariant.

4°. The introduction of invariant dyadics Ξ and their application to the problem of finding the scalar invariants of the product $\Omega\Phi$.

5°. The fact that in case the Hamilton-Cayley equation of $\Omega\Phi$ is the equation of lowest degree, there may be found a $\Phi = I - 2\,\bar{\sigma}|\sigma$ such that the scalar invariants of the product are arbitrary. The corollary that in such cases, if $\Omega_n = \pm 1$, Ω be written as the product of three square roots of the idemfactor with the appropriate interpretation in the theory of reflections.

6°. The determination of the necessary and sufficient conditions that a dyadic be resoluble into the product of three square roots of the idemfactor, with an example to show that it is not always possible to take a square root of type 1 as the first of the three.

Massachusetts Institute of Technology,
Boston, Mass., December, 1907.

N. Y. ACADEMY
OF SCIENCES

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 59-170 DECEMBER, 1908

The Morphology of Ruppia Maritima

BY

ARTHUR HARMOUNT GRAVES, Ph.D.
INSTRUCTOR IN BOTANY IN YALE UNIVERSITY

PUBLISHED UNDER THE AUSPICES OF
YALE UNIVERSITY

NEW HAVEN, CONNECTICUT
1908

WEIMAR : PRINTED BY R. WAGNER SOHN

CONTENTS

PLATES I –XV.

PAGES

INTRODUCTION 65

MORPHOLOGY OF THE VEGETATIVE ORGANS . . . 69

STEM 69

A. General Characters 69

B. Branching 69

1. Branching in *Ruppia maritima* 69

a. Vegetative Branch System 69

b. Inflorescent Branch System 71

2. Comparative Study of the Branching of the Potamogetonaceae 72

C. Anatomical Structure 74

1. Growing Point 74

2. Stem Structures in the Vegetative Region . . . 75

a. Upright Stem 75

(1) Epidermis 75

(2) Cortex 75

(a) *Outer Cortex* 76

(b) *Middle Cortex* 77

(c) *Inner Cortex* 77

(3) Endodermis 78

(4) Vascular System 78

(a) *Course of Vascular Bundles* 78

(b) *Structure of Vascular Bundles* 80

b. Rootstock 82

3. Stem Structures in the Floral Region 83

a. Peduncle 83

(1) General Characters 83

(2) Anatomical Structure 83

(3) Coiling of the Peduncle 85

b. Rhachis 85

c. Stipe 85

4. Brief Comparative Study of the Stem Anatomy of the Potamogetonaceae 86

LEAF 86

A. Enumeration of Kinds of Leaves 86

B. Arrangement 86

C. Ordinary Foliage Leaves 87

PAGES

1. The Leaf Blade 89
   a. Epidermis 90
      (1) Chloroplasts 90
      (2) Marginal Teeth 90
      (3) Secretion Cells 90
      (4) Absence of Stomata 91
   b. Subepidermal Layer 91
   c. Vascular System 91
      (1) Course of Vascular Bundles 91
      (2) Structure of Vascular Bundles 92
   d. Lacunae 92
   e. Comparison with Other Potamogetonaceae . . . 92
2. The Stipular Sheaths 93
   a. Structure 93
   b. Development 93
   c. Function 93
   d. Morphological and Morphogenetic Considerations . 95
3. Axillary Scales 96
   a. General Characters and Anatomy 96
   b. Function 97

D. Subfloral Leaves 97

E. Scale Leaves 98
1. The Vegetative Scale Leaf 99
   a. General Characters 99
   b. Internal Structure 99
2. The Floral Scale Leaf 99
   a. General Characters and Structure 99
3. Orientation of Scale Leaves in Floral Region . . . 100
4. Summary of Distinguishing Characters 101
5. Morphological and Physiological Nature of Scale Leaves 102
6. Comparison with Other Potamogetonaceae . . . 102

Root 102

A. General Characters 102

B. Root Arrangement 103

C. Anatomical Structure 104
1. The Coleorrhiza 104
2. The Growing Point of the Root 108
3. The Anatomy of the Mature Root 109
   a. Epidermal Region 109
      (1) The Root Hairs 110
   b. Cortex 111
   c. Endodermis 111
   d. Vascular System 112
   e. Brief Comparative Study of Roots of Other Potamogetonaceae 112

D. Functions of the Root. 113

PAGES
ECOLOGY OF THE VEGETATIVE ORGANS 115
Introductory 115
Hydrophytic Adaptations 116
A. The Shoot 116
1. Gross Morphological Adaptations 116
2. Internal Structural Adaptations 117
a. Epidermal Modifications 117
b. Development of Air Spaces 118
c. Absence of Mechanical Tissue 119
d. Reduction of the Vascular System 119
B. The Root 120
1. Gross Morphological Adaptations 120
2. Internal Structural Adaptations 121
a. Air Spaces 121
b. Reduction of the Vascular System 121
Halophytic Adaptations 121
A. General 121
B. The Adaptation to a Salt Water Environment . . . 122
Adaptation and Heredity 126
Summary 126
REPRODUCTIVE ORGANS 128
Morphology of the Flower 128
Floral Development 130
Microsporangium 131
Megasporangium 135
Female Gametophyte 136
Male Gametophyte 139
Pollination 143
Fertilization 144
Endosperm 145
EMBRYO 146
FRUIT AND SEED 156
SEEDLING 158
SUMMARY OF PARTS ON REPRODUCTIVE ORGANS, EMBRYO, &c. 160
SUMMARY OF RELATIONSHIPS TO OTHER POTAMOGETONACEAE 162
BIBLIOGRAPHY 165
EXPLANATION OF PLATES 170

INTRODUCTION

Of late years there has been manifested a tendency toward a systematic investigation of the internal structure of plant species, as contrasted with the more superficial description of external characters by systematists. For although, as stated by Campbell (1897), a description of external characters "is usually quite sufficient for the mere identification of a plant, and for determining its relation to nearly allied forms, it is quite inadequate for settling questions of relationship between more remote groups, and especially those of obscure affinities."

This movement has been directed especially to the study of the origin and development of the sexual generation in Spermatophytes and the problems of embryology in this group, resulting in an overwhelming mass of literature on these subjects.

But, in the meantime, it is commendable that some botanists have also directed their attention to a study of the internal structure of the vegetative organs; for it is only by a complete account of the development and structure of the whole plant, together with its life history, that we can hope to acquire sufficient knowledge for the solution of one of the most interesting and vitally important problems in all plant morphology—i. e., the interrelationship of the various plant groups.

Some of the recent works of Campbell (1897, 1898) are most noteworthy in presenting in this way a connected account of several species, especially certain little understood monocotyledons.

The present work, extending over a period of five years, was undertaken with a similar purpose; and seeks to comprehend, as far as possible, a connected account of the development and structure of the plant organs, together with the life history, of one of the simpler monocotyledons, *Ruppia maritima*.

The Potamogetonaceae of Ascherson (1889) to which the genus Ruppia belongs, comprise an interesting family of remarkably simple plants. As to whether this simple structure represents a primitive or a reduced condition is an extremely important question, but in the present state of our knowledge a clear, unassailable verdict on either side is impossible. A discussion of this point will, however, be postponed for the present.

A few remarks may be in order here as to the literature which relates to the subject of this paper, and which I have found most helpful in its preparation. Ascherson (1889), in Engler and Prantl's Natürliche Pflanzenfamilien, cites the most important references bearing on the Potamogetonaceae up to the date of his contribution. Among these, the papers on Althenia by Prillieux (1864), Cymodocea by Bornet (1864), and Zostera by Grönland (1851) are valuable for their contributions to the morphology of these allied plants. In this respect, also, the works of Irmisch (1851 and 1858) are remarkable for the accuracy with which they describe the external morphological relations of *R. rostellata* and other Potamogetonaceae. Of later works, which are especially useful in a comparative morphological study of the vegetative organs, are, among others, those of Sauvageau (1891, II), Campbell (1897) and Goebel (1898). As to ecological considerations pertaining to water plants, the work of Schenck (1886) deserves especial mention. In the preparation of the parts on the reproductive organs, embryo, &c., the works cited are too numerous to mention here, and the reader is referred to the bibliography (p. 165).

If we except a rather doubtful reference of Hofmeister, (1861, Figures 1–7, Pl. II, and see p. 148 of this paper), the only investigation of *Ruppia maritima* which has ever been published, so far as I can ascertain, is that of Roze (1894), who describes chiefly the conditions of fertilization, but also presents a valuable historical review of the whole genus. Others, it is true, such as Miss Scott (1906) and Chrysler (1907), have dealt with special features of the plant, in the course of their comparative morphological investigations.

Ruppia rostellata, on the other hand, if we piece together the results of various observers, has been pretty thoroughly worked out. First Irmisch (1851 and 1858) described carefully its external morphological characters; next, Wille (1883) studied the development of the embryo, and quite recently Murbeck (1902) published an admirable paper on the reproductive organs and embryo.

The genus Ruppia is aquatic, characterized by its long, linear, grass-like leaves with basal sheaths, and grows in brackish and salt water (but probably never salt water of normal ocean strength, see p. 124), in creeks and bays along the coast and in the neighborhood of inland salt springs, throughout all parts of the temperate and tropical zones. Except at low tide it is completely submerged until the period of flowering, when it produces its flowers a short distance (1–3 cm.) above the surface of the water. The flowers, always two to each peduncle, are borne one above the other, on

opposite sides of the rhachis, the latter being homologous to a spadix, but not at all fleshy. The flowers are naked and consist of two practically sessile anthers, each with its two large sacs or thecae separate and arranged transversely on the rhachis, making a diamond-shaped arrangement, in the center of which is a group of pistils, always four in number in the specimens I have examined (Pl. IX, fig. 49).[1] After the shedding of the pollen, the pistils if fertilized develop a stipe or pedicel of considerable length (Pl. IV, fig. 13). The peduncle, or floral axis, however, elongates whether fertilization is consummated or not. After fertilization the fruit is drawn below the surface of the water, the elongated peduncle usually coiling up to aid in this process (see p. 85).

In company with most of the submerged plants, Ruppia is perennial. The majority of the leaves and stems die at the approach of cold weather, leaving the living rootstock buried in the mud. Some green leaves, however, remain, connected with the rootstock, and lie at the bottom of the ditch or pool, so that it is possible to collect all of the vegetative organs all winter.

One locality, indeed, is worthy of note, where *Ruppia maritima* flourishes all winter. Here, possibly on account of springs, the water is tempered somewhat, and I have gathered Ruppia in a green, vigorous condition, when the surface of the ditch was covered with ice over an inch in thickness. Although there are doubtless springs here, the water nevertheless contains a large percentage of salt. It is quite possible that there are many other similar locations where Ruppia grows all through the winter.

In no case, however, have I found the bulbous winter buds, which have been noted in the Potamogetons by Irmisch (1858).

As indicated by Britton and Brown (1896 vol. I, p. 79), considerable variation exists in *Ruppia maritima*. Thus, one form which I have noticed especially, is of a more slender habit, with narrower leaves and stems than those of the ordinary individual. Its branching is ultimately quite irregular, although the system accords with that of the normal form. This form grows in quiet pools.

There is, moreover, still considerable uncertainty as to the number of existing species of Ruppia (Ascherson, 1889; Sauvageau, 1891, II, p. 209; Roze, 1894, p. 479). The question is such a large one that it cannot be discussed here, and would require, besides, a careful study of herbarium material from different parts of the world. I will only state that as far as I can learn from a study of systematic

[1] But see Roze, 1894, p. 479.

descriptions and figures (Griffith, 1851, I–II; Irmisch, 1858; Hillebrand, 1888; Ascherson, 1889; Sauvageau, 1891, II; Hooker, 1894; Roze, 1894; Britton, 1907), four species may be safely recognized; namely, *R. maritima* L., *R. rostellata* Koch, *R. brachypus* Gay, and *R. occidentalis* Wats.

All of the material for the present work was collected in tidal ditches in Fort Hale Park, near New Haven, Conn. Here it grows in abundance, forming large tufts with its grass-like leaves, which follow easily the direction of the current. At extreme low tide a large portion of the plant floats, but at high tide it is completely submerged. The period of flowering commences in June and continues until the severe frosts in autumn, up to which time, even in October, I have gathered flowers in good condition.

The material was killed either in chromacetic acid, Flemming's solution, or Keyser's fluid. The first seemed the best, although the others gave good results. Several stains were used: for general work haematoxylin and erythrosin; for cytological study in the development of the male and female gametophytes, &c., and the embryo, the triple stain was used with excellent results. For the latter investigations Heidenhain's iron haematoxylin was also found to be good. In all, about 20,000 microtome sections were cut of the different parts of the plant. For all of the microtechnique Chamberlain's "Methods in Plant Histology" was found invaluable, and in all preparations the directions given therein were closely followed.

I would like to avail myself of this opportunity to express my gratitude to Professor Alexander W. Evans, Eaton Professor of Botany in Yale University, for the great interest he has taken in the work and for the invaluable criticism and suggestions which he has been ever ready to give. I desire also to thank Professor W. R. Coe, Professor J. W. Toumey, and Dr. A. L. Dean, of Yale University, for their kindness in offering suggestions, material, &c.

THE MORPHOLOGY OF THE VEGETATIVE ORGANS

Stem

A. General Characters

Under the heading of "Stem" may be classed several parts of the plant, all of which are cauline in their morphology and origin, but differ to some extent in their functions and relations to the other parts of the plant. The horizontal axis, which lies prostrate on the soil, bearing the roots and upright shoots, may be termed the *rootstock*;[1] the axis of the upright shoot may for convenience be designated the *stem*; the parts which bear the flowers and fruit we may speak of respectively as *peduncle*, *rhachis*, and *stipe*.

In general, all these parts are slender, terete, and of a whitish color, although the stem at times assumes a greenish tinge due to a small content of chlorophyll.

I shall consider first the branching and anatomy of the stem and rootstock; next, the development of the stem structures which are connected with the production of flowers and fruit, comparing their anatomy with that of the first two structures.

B. Branching

1. Branching in *Ruppia maritima*.

Two principal systems of branching occur in Ruppia: one in stem and rootstock and connected with the ordinary growth, which we may call the vegetative branch system; and the other in the stem only, and associated with the production of flowers, which we may therefore designate the inflorescent branch system.

a. Vegetative Branch System.

The vegetative branch system is a distichous monopodium, the branches being borne alternately on opposite sides of the axis and in the same plane. In the rootstock, indeed, except near its growing point, this initial arrangement is generally later much obscured, due to the upward growth of many of the lateral branches (Pl. VII.

[1] As will readily be seen—a point which will be brought out more clearly later (p. 82)—the rootstock does not differ from the stem from a morphological point of view, either externally or internally; for any stem, by becoming horizontal and producing roots at the nodes, assumes the character of what I have termed the rootstock.

fig. 36). In the case of the stem, however, the natural arrangement often remains apparent (Pl. I, fig. 2; Pl. II, fig. 6).

On account of this distichous system, it is possible to cut a longitudinal section through all of the branches and the stem at the same time, especially if the region of the growing point is selected, as is represented in Pl. I, fig. 1 (cf. Pl. VI, fig. 25).

A study of this figure of a vigorously developing stem apex will show clearly the order of development and the orientation of the branches. Since the origin of the branches is inseparably connected with the leaf development, it will be necessary to include in a description of the figure some reference to leaf development.

The apical growing point $G\ P$ has given off in alternate succession the primary leaves L^{I}, L^{II}, L^{III}, L^{IV}, &c. A secondary growing point arises in the axil of each of these leaves, which develops leaves in the same manner. The first leaf, however, is a scale leaf, which will be discussed at length later. (See p. 99.)

Since L^{I}, L^{II}, L^{III}, L^{IV}, &c. are developed in acropetal succession and hence show equal gradations in age, a study of their successive axillary structures presents a clear idea of the manner of development of the branch. The youngest leaves, L^{VIII} and L^{VII} are hardly more than protuberances from opposite sides of the growing point, and as yet reveal no structures in their axils. At L^{VI} we first see a small axillary growing point—the beginning of a branch. In the axil of L^{V} the rudimentary scale leaf, $v\,s\,l$, appears on the left of the growing point $g\,p^{(V)}$. At the base of L^{IV} we find the scale leaf ($v\,s\,l$) in its normal position, and also on the left of the growing point point the first vegetative leaf of the branch, $l_1^{(IV)}$. The axils of L^{III} and L^{II} show successively advanced stages until in L^{I} appear four leaves of the branch besides the scale leaf;—$l_1^{(I)}$, $l_2^{(I)}$, $l_3^{(I)}$ and $l_4^{(I)}$. Moreover in the axils of $l_1^{(I)}$ and $l_2^{(I)}$ appear young growing points to form branches of a second order.

Such a growing point under ordinary conditions will develop in a regular way for some time, the leaves and axillary shoots appearing in acropetal succession and the nodes of increasing length basipetally, according to their age. This stage is represented in Pl. I, fig. 2, a sketch from a living specimen.

Sooner or later, however, in the course of the development of the system, its regularity becomes more and more modified to suit environmental relations, a condition which is of course true of any branch system. Pl. II, fig. 6 is a drawing from nature of the upper portion of a plant whose vegetative branch system has undergone

considerable modification in this way. The period of blooming is at hand, and although no flowers have yet appeared, we find flower buds at the ends of the lateral branches as well as at the termination of the main shoot itself.

Some of the modifications here exhibited are the varying orientation of nodes and internodes—an arrangement evidently brought about to obtain the most advantageous light, space, &c.;—the irregularity in length of internodes, those at the base of the plant being not necessarily the longest; and the number of leaves borne on the branches previous to the development of flowers, for since the latter must bloom above the surface of the water, the lowest branches must necessarily be longer and hence bear more leaves.

In its development of flower buds, the case is a good illustration of the manner of change from the vegetative branching to the inflorescent type, as described below.

b. Inflorescent Branch System.

Irmisch (1851) has accurately described the inflorescent type of branching in *R. rostellata*, but for the sake of completeness and confirmation in *R. maritima*, I will review the more important points.

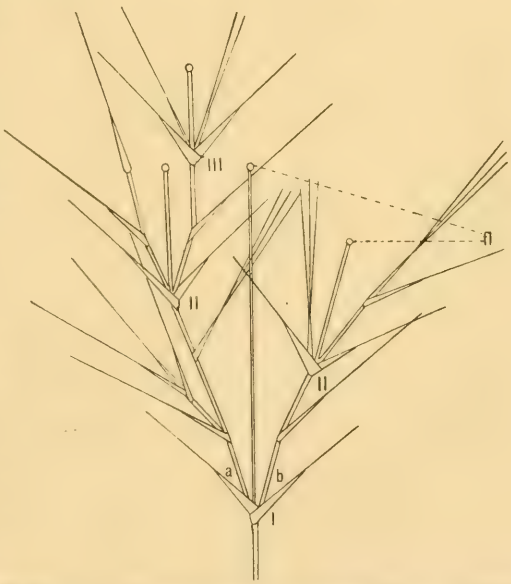


Figure 1.—Diagrammatic representation of inflorescent branch system; *a* and *b*, stronger and weaker shoots respectively; *I*, *II*, and *III*, successive generations of sympodial development; *fl*, flower.

When the upright or upward growing branches arrive at or near the surface of the water, their apices terminate in inflorescences, as shown diagrammatically in Text-fig. 1, consisting of a slender peduncle and a rhachis homologous to a spadix, the latter bearing always two flowers. From now on the inflorescent type of branching prevails. For from the axil of each of the two nearly opposite leaves subtending the peduncle (see p. 97 ff.) arises a secondary branch (Text-

fig. 1, *a* and *b*), which continues the growth of the stem. Of these branches, that in the axil of the upper leaf (Text-fig. 1, *a*) is invariably of stronger growth, exceeding considerably the branch on the other side of the floral axis. These axillary branches, after forming a few leaves, terminate in flowers again, and the process of branch formation is repeated. In this way, since the main axis is continued by the stronger branch, the system in the region of the flowers is sympodial. In most instances, however, the weaker axillary branch has a fairly vigorous development, as in Text-fig. 1, in which case the branching approximates a false dichotomy, and a characteristic fan-like form is thus often produced.

In Text-fig. 1 the branch *a* develops two ordinary leaves before it terminates in a flower. This brings the upper of the pair of subfloral leaves at the right side instead of the left, as at I. Such an arrangement as this is not as common as is the continual production of the stronger branches on the same side of the stem, but in this way also the fan-like form may be attained.

2. Comparative Study of the Branching of the Potamogetonaceae.

In Zannichellia, Campbell (1897, pp. 38 ff.) finds that the apex of the stem divides into two equal parts, one of which develops into the female inflorescence, while the other continues as the main axis of the stem. Farther on he says "the inflorescence is the result of the dichotomy of the main shoot, whose other member continues the growth of the axis." So that, although a sympodium is the ultimate result, it is attained by a dichotomy of the growing point, one of the branches becoming a male or female flower. Schumann's (1892) interpretation had been somewhat different from this, maintaining that the female inflorescence terminated the main axis and that the growth of the shoot was continued by an axillary branch arising in the upper of the two subtending leaves. The position of these leaves much resembles that of the subfloral leaves of Ruppia, so that if Schumann's idea were correct, the inflorescent branch system of Zannichellia would be a sympodium similar in origin and development to that of Ruppia.

Campbell's figures, however, show a vigorous, simultaneous development of the primordia of both flower and main axis, which lend to his theory a great deal of weight. In Ruppia the primordium of the axillary shoot arises much later than that of the flower, so that such a dichotomy as Campbell claims is here impossible. (See Pl. IX, figs. 54–56.)

Irmisch (1858) investigated the vegetative branching of Zannichellia and found it to be a pure sympodium as regards its horizontal axis. This develops beyond its second leaf into an upright shoot, which ultimately bears the flowers; at its base, however, from the axil of the second leaf, arises a branch which prolongs the horizontal axis. This again, after two leaves are given off, develops into an upright shoot and the horizontal axis is again repeated from a branch in the axil of the second leaf. This process goes on indefinitely, so that the horizontal axis is therefore merely a succession of generations of axillary branches and hence a pure sympodium.

The branching of Naias is peculiar, according to Campbell's (1897) interpretation. The leaves are developed approximately in pairs—one slightly below the other and larger. From the axil of this lower one a primordium arises which by dichotomy produces a flower and a lateral branch. The branch bears at its base a single leaf. The upper leaf of the original pair is sterile, so that the stem of Naias has its leaves apparently in whorls of three, with a branch and flower arising from each whorl. Apparently the apex of the main stem never terminates its growth, but goes on producing its pairs of leaves—one sterile and one fertile—so that the system is very unlike that of Ruppia.

Cymodocea, an entirely submerged marine genus, distinguished by its long ribbon-like leaves, very simple flowers and filamentous pollen, is placed by Ascherson (1889) next in order to Ruppia. In *Cymodocea nodosa*, Bornet (1864, pp. 15 ff.) describes types of branching which conform to those of Ruppia. The vegetative branching is monopodial, and a longitudinal section of the bud (l. c. Pl. IV, fig. 1) resembles very closely that of Ruppia. The flowers are terminal and the growth in length is continued by a lateral bud. It appears, however, that this bud is not necessarily one of the two buds nearest the flower.

In Zostera the rootstock is also monopodial, the inflorescent system being sympodial (Sauvageau, 1891, I).

Phyllospadix closely resembles Zostera (Dudley, 1893).

In Althenia (Prillieux, 1864), on the other hand, a genus resembling Zannichellia and found in Europe, Africa and Australia, the vegetative branching is sympodial, much as in Zannichellia. The growth of the rootstock is continued by successive branches from the horizontal axis which in each case itself becomes vertical and bears the flowers. The flowers are unisexual—the male terminating the upright axis or stem. In the axils of the two leaves subtending the male flower arise secondary branches, which bear male or

female flowers, but more often the latter. From these, branches of the third order arise, and in this manner a complex sympodial development is the rule.

Irmisch (1858) found that the vegetative branching of *Potamogeton lucens*, *natans*, *crispus*, *obtusifolius*, and *pectinatus* was purely sympodial as to the rootstock, just as it is in Zannichellia and Althenia. It is very probable that the other Potamogetons have the same system. As to the floral system the branching is sympodial.

Summary. The branching of Ruppia is of two main types:—a sympodial system occurring in the region of the flowers, and a monopodial system present in all other parts of the plant.

Zannichellia, Althenia, and Potamogeton have, however, a sympodial system in the case of the rootstock, but a purely monopodial development like that of Ruppia occurs in Cymodocea, Phyllospadix, and Zostera. With the exception of Zannichellia, where Campbell finds a true dichotomy, all these genera have a similar inflorescent branch system—a single or double sympodium formed from branches in the axils of the two characteristic subfloral leaves, or at any rate from a lateral bud as in Cymodocea.

C. Anatomical Structure

1. Growing Point.

In a good median section the growing point of the stem reveals the three divisions of primary tissue more or less clearly marked: the whole is covered by a layer of dermatogen; beneath this lies the periblem, composed of usually one layer and surrounding the three or four layers of plerome cells.

Text-fig. 2, besides demonstrating these meristematic divisions, shows an interesting very early stage in the development of the youngest leaf. Here the periblem on the right has undergone several divisions preparatory to the formation of the youngest leaf primordium, which is destined to appear at this region, opposite the next youngest leaf, L^{II}.

On the whole, the arrangement of cells and young lateral organs is very similar to that figured by Douliot (1890) for *Cymodocea aequorea*.

2. Stem Structures in the Vegetative Region.

a. Upright Stem.

In its internal structure the stem is remarkable in many respects, but chiefly because of the reduction and consolidation of the vascular system into what may be termed a single axial vascular bundle, if we except the two minute bundles situated in the cortex. The morphogenesis of this reduced structure, as well as the structure of the whole stem as regards its adaptability to its environment, will be considered more in detail later.

The epidermis surrounds a large zone of cortical parenchyma cells with a ring of lacunae in their midst; these cortical cells adjoin an endodermis, which encloses the axial vascular area (Pl. I, figs. 4–5; Pl. III, figs. 7, 8 and 9). The four parts —epidermis, cortex, endodermis and vascular system will now be described in order.

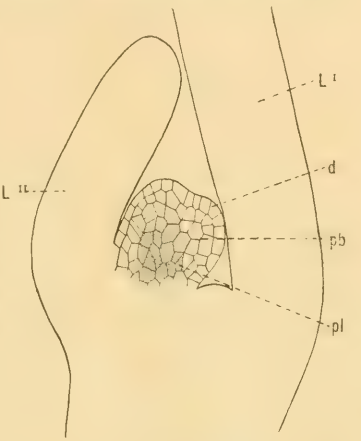


Figure 2.—Longitudinal section through growing point of stem, showing origin of youngest leaf primordium in the periblem; *d*, dermatogen; *pb*, periblem; *pl*, plerome; *L I*, *L II*, older leaves. × 210.

(1) Epidermis.

The epidermal cells are small in comparison with the cortical parenchyma cells and much smaller than the epidermal cells of the root (Pl. I, fig. 5). Their walls are thin, and yet thicker than the walls of the interior cells, the free wall being slightly thicker than the others. Occasionally these cells contain a small amount of chlorophyll.

As might be expected from a comparison with other submerged plants already investigated (Schenck, 1886), no stomata occur throughout the plant.

In the epidermis, rather regularly distributed over the stem, but especially abundant in the region of the nodes, are secretion cells, which are, however, more numerous in the leaf, and will be described more in detail there (see p. 90). These cells occur scattered here and there also in the cortex, and some may be seen in the axial vascular bundle.

(2) Cortex.

The typical cortical parenchyma cells are large in comparison with the cells of the epidermis, endodermis and vascular tissue; they are

rounded so that intercellular spaces often occur, and elongated in the direction of the length of the stem (Pl. I, fig. 5; Pl. III, fig. 7; Text-fig. 3). The majority of the cortical parenchyma cells show in an oblique view parallel horizontal stripes or bands on their side walls. A longitudinal section proves that this appearance is due not to bands of thickening, but to slight undulations (Text-fig. 3). These are not necessarily regular in size or distance apart; they may or may not occur all through the cell, and certain cells are apparently entirely without them. Their function is not clear. Similar undulations were observed by Caspary (1858) in several aquatic plants, notably in *Zannichellia palustris*. Prillieux (1864) has also noted them in the stem of *Althenia filiformis* and in the roots of epiphytic orchids.

Figure 3.—Longitudinal section of a portion of cortical parenchyma cells, showing undulations in the side walls. × 210.

Another point of general interest in the stem cortex is the occurrence of starch grains. These, as shown in Pl. I, fig. 5, are quite numerous. Their size evidently increases in the vicinity of the axial and cortical bundles and everywhere at the nodes. Irmisch (1858, p. 35) has found starch abundant in the Potamogetons and has described its occurrence and appearance in considerable detail.

In the cortex appear also the secretion cells noted in the epidermis, that is, they are apparently of the same nature, behaving in general in a similar way. They do not contain starch, as do most of the cortical cells, but are filled with fine granular contents and are especially abundant at the nodes. Bornet (1864, pp. 40–41) has noted cells evidently quite similar in the cortex and vascular tissue of Cymodocea, filled with a "liquide oléagineux, un peu teinte de jaune, tout-à-fait semblable à celui que renferment les cellules épidermiques des anthères."

In describing the cortex we may for convenience divide it into three portions: (a) an outer zone of cells, compactly arranged and bounded on the outside by the epidermis; (b) a central area, with a large portion of its territory occupied by a ring of lacunae or air spaces; and (c) an interior zone of cells limited on the inner side by the endodermis (Pl. I, fig. 5).

(a) *Outer cortex.*

The outer portion of the cortex consists of two or three layers of cells (Pl. I, fig. 5 *oc*; Pl. III, fig. 7). The cells of the outermost

layer are much larger than those of the epidermis, but partake somewhat of the nature of the latter in their slightly thickened walls. Toward the outer part of this cortical region intercellular spaces rarely occur: instead the triangular prismatic areas which the spaces would occupy are filled with thickening and probably supplement the firmness imparted to the stem by the epidermis.

It is in this outer portion of the cortex that two small vascular bundles occur, which may be termed cortical bundles (Pl. I, figs. 4, 5, *cb*). An account of these will be given in connection with the vascular system.

Toward the interior of this zone the cells increase in size, and intercellular spaces begin to appear.

(b) *Middle cortex.*

The most striking feature of the middle area of the cortex is the ring of large air spaces or lacunae (Pl. I, figs. 4, 5, *mc* and *la*; Pl. III, fig. 7). These originate schizogenously by a splitting apart of the walls of adjacent cells when these are in a very young stage, and subsequently they become much enlarged. A ring of from twelve to eighteen is disposed in a fairly symmetrical way in this central part of the cortex. As a rule somewhat elongated radially, they are separated from each other laterally by a single column of cells. In length up and down the stem they extend from node to node, no diaphragms being stretched across as in the leaf lacunae. Communication through the node is maintained by means of small intercellular spaces.

Between the lacunae and the small intercellular spaces occurring near the inner and outer limits of the cortex lie many air spaces of intermediate size, so that although the large lacunae appear quite distinct on account of their large size and fairly regular arrangement, yet gradations exist between them and the small triangular intercellular spaces (Pl. I, fig. 5).

(c) *Inner cortex.*

The interior zone of the cortex, terminating with the endodermis (Pl. I, fig. 5, *end*), is a good deal similar to the outer zone. The cells and intercellular spaces gradually decrease in size, and the latter also in frequency, toward the endodermis, while the cell walls gradually increase in thickness.

A striking peculiarity of the cells of this inner cortical zone is their chlorophyll content, which is very noticeable in freehand sections from fresh stems. It was definitely ascertained that the chlorophyll grains belong to these cells and were not drawn inward from the epidermis by the razor.

(3) Endodermis.

The endodermis is a fairly regular layer of cells surrounding the central vascular region (Pl. I, fig. 3). On the application of concentrated sulphuric acid all the walls of the endodermal cells become beautifully undulated, the radial walls showing a stronger suberization. In many cases the ring of cells outside of the endodermis is also quite strongly suberized and therefore withstands to a considerable extent the action of the sulphuric acid (Text-fig. 4). No U-shaped stripes of thickening appear on the walls, such as were seen by Schenck (1886) in *Potamogeton pectinatus* and other species. Although a banded appearance is produced in a slightly oblique view, a longitudinal section shows that it is due merely to the slightly undulating walls, essentially as has been shown in the cortical cells. The radial walls, however, are slightly thickened uniformly.

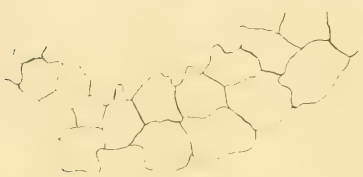


Figure 4.—Cross section of portion of endodermis and next outer ring of cells treated with concentrated sulphuric acid, showing slightly thickened radial walls. × 400.

(4) Vascular System.

One of the most interesting features of the stem is its remarkably simple vascular system. This comprises two small cortical bundles and a larger central bundle (Pl. I, fig. 4; Pl. III, fig. 7). I shall describe first the course of these bundles, and then turn to a description of their anatomical structure.

(a) *Course of Vascular Bundles.*

The course taken by the vascular bundles in the stem is very simple. The main central bundle travels in the center of the stem, and at each node sends off two branches in the manner figured (Pl. V, fig. 17)—a large branch to the lateral member which almost invariably occurs at each node, and a smaller contribution to its subtending leaf. This is repeated at each succeeding node until the floral region is reached. Here the main bundle continues to its termination in the rhachis, but gives off on each side a couple of branches to the lower and upper subfloral leaves with their axillary members in turn. This is simply a repetition of the process occurring at then odes, except that here, between the lower and upper subfloral leaves, the node is practically obliterated (Pl. V, fig. 18). This arrangement, at least in the vegetative region, is much like that of *Potamogeton pectinatus*, described and figured by De Bary (1884, p. 273).

The course taken by the cortical bundles, although simple, is not quite as evident. The cortical bundles are entirely independent of the central bundle, never connecting with it, so far as I have been able to ascertain. Their position can be best shown by the use of figures selected from a series of cross sections. A cross section in the region of a node, just below the point where the leaf is given off, is represented in Pl. V, fig. 19. Here the cortical bundles are situated in the outer cortex, not quite diametrically opposite each other. This figure also shows the axial bundle somewhat dilated radially. Pl. V, fig. 20 shows the edges of the leaf sheaths appearing at the cleft at the upper side of the figure. The cortical bundles occupy about the same position as before, but the axial bundle is commencing to give off its two branches—to the leaf and axillary branch. In Pl. V, fig. 21 the leaf sheaths are still more separated from the stem; the two large leaf and branch bundles are now distinct from the axial stem bundle; the cortical bundles have moved outward slightly, and a new cortical bundle appears nearer the central bundle. Since the section is cut slightly obliquely, and the right side represents a portion higher up in the stem, only one of the pair of new cortical bundles thus appears. Pl. V, fig. 22 shows both, however, and also represents the former pair of cortical bundles as moving gradually into the still further separated leaf. Pl. V, fig. 23 shows the leaf with its lateral (cortical) bundles, separate from the stem, and fig. 24 does the same for the branch which it subtends.

It is clear, therefore, that the cortical bundles of the stem furnish the lateral nerves of the leaf. It will be seen also that not only do the cortical bundles have no connection with the axial bundle, but also that a new pair arises at each node to pass into the leaf at the node next higher up. After a careful examination, I find absolutely no connection between these successive pairs of cortical bundles.

Although the figures and description of De Bary (1884, p. 274) for *Potamogeton crispus* seemed to present an arrangement similar to the above, the work of Chrysler (1907), which appeared while this paper was being prepared for publication, corrects De Bary's account but confirms my investigation of *Ruppia maritima*. Chrysler's conclusion (l. c. p. 171) is undoubtedly correct that "this condition has in all probability been derived by reduction from that in which the cortical bundles joined the central cylinder at the next node below the insertion of the leaf to which they belong."

The cortical bundles of *Zostera marina* (De Bary, 1884, p. 275;

Sauvageau, 1891 I ; Chrysler, 1907) are similar to those of Ruppia, but are continuous up and down the cortex and send a branch to the central cylinder at the nodes.

(b) *Structure of Vascular Bundles.*

Anatomically the cortical bundles in a young stage consist of small, closely packed cells, which are all tracheids or tracheae (Pl. III, fig. 8). No sieve tubes can be distinguished (Text-fig. 5). At a later stage (Pl. I, fig. 5 ; Text-fig. 6) these small elements have for the

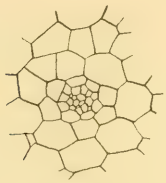


Figure 5.—Cross section of cortical bundle, before dissolution of its vascular elements. × 210.

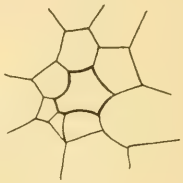


Figure 6.—Cross section of cortical bundle, after dissolution of its vascular elements. × 300.

most part been resorbed, so that only a passageway remains, except at the nodes, where they remain intact.

In structure, the central cylinder is composed of a central xylem region surrounded by a zone of phloem. The xylem is in a young stage represented by a group of tracheae at the center, which, however, very early in the development of the stem, become pulled apart and disorganized except at the nodes, where they are conspicuous in the mature stage. The resulting space, then, is a lysigenous cavity, and does not represent an enlarged cell (Pl. I, fig. 3). The thickenings of the tracheae are mostly annular, although spiral and other forms may occur (Text-fig. 7). Occasionally these thickenings may be found lying loose

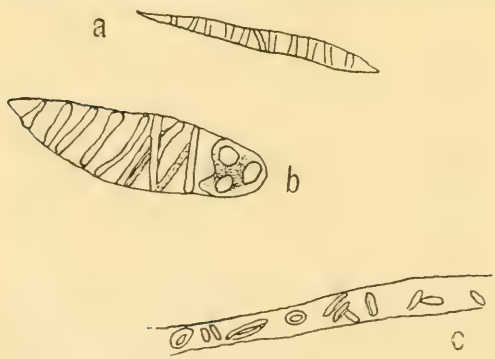


Figure 7.—Tracheae and tracheids from axial vascular bundle of stem: a. tracheid with annular thickenings ; b. tracheid with annular, spiral, and pitted thickenings ; c. disorganized trachea with thickenings lying in the cavity. × 1350.

in the central lysigenous opening. In sections of the stem it appeared as if tracheids were also present, especially at and near the nodes, possessing the same characters as to their thickenings as the tracheae, but showing cross walls (Text-fig. 7 *a*, *b*).

Surrounding the central cavity are thin-walled xylem parenchyma (Pl. I, fig. 3). Just outside of these lies the phloem region, the boundary between the two being impossible to determine on account of the apparently identical characters of the xylem and phloem parenchyma.

In the phloem zone are distributed the sieve tubes, with their companion cells, in an irregular ring in much the same way as in Zannichellia (Schenck, 1886). As a rule, the sieve tubes are larger than the surrounding cells, and on this account and because of their arrangement in a ring, each with its companion cell, they stand out quite clearly even in freehand sections. Between them and the endodermis lie one or occasionally two layers of parenchyma cells (Pl. I, fig. 3).

One noteworthy feature of the phloem region is that in the vicinity of the node, i. e. immediately before and after the branches are given off from the central cylinder, it is localized into four distinct symmetrically situated portions (Text-fig. 8), although this is never evident in the internodal region. Such an arrangement would be expected when one considers the true nature of this fibrovascular area, as described below, and compares it with certain Potamogetons which reveal this character more distinctly (Schenck, 1886. pp. 40–41 and figures 35, 36 and 38), and with *Zostera marina* (Chrysler, 1907, p. 172 and fig. 29).

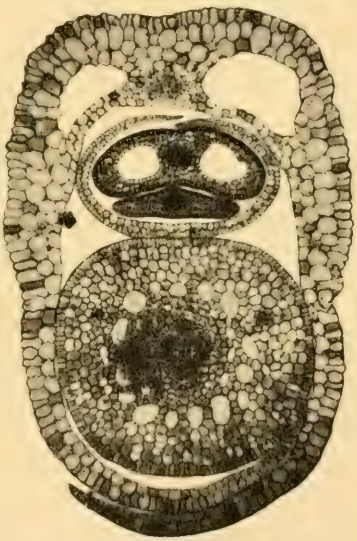


Figure 8.—Photomicrograph of cross section of stem, &c., similar to Pl. III, fig. 8, but cut at a higher plane and near a node; showing localization of phloem into four regions in central cylinder of stem. × 35.

In his work already cited, Schenck (1886, pp. 27 ff.) reviews in a most admirable manner the various interpretations of the concentric type of bundle as it exists in water plants. He concludes with Sanio and Russow that it represents phylogenetically not a single

bundle, but the product of the gradual centripetal union of many stem bundles, and is therefore not comparable to the concentric bundle of the majority of the Gleicheniaceae, for example. This is true both of mono- and dicotyledonous water plants.

In support of this theory Schenck shows how there exists at the present time in different aquatic and amphibious species, every gradation from the typical bundle arrangement common to land plants to the simplest structure as exemplified in the submerged aquatics. He says, "Im Laufe der phylogenetischen Entwicklung rückten infolge immer weiter gehender Anpassung der Structur an die Lebensweise der Pflanze unter Wasser diese Leitbündel bei gleichzeitiger Reduction des Xylems nach der Axe zusammen zu einem gemeinsamen Strang, in welchem die Xylemteile nach und nach zu einem einzigen axilen Körper verschmolzen, während die Phloemteile, ihre normale Lage nach außen beibehaltend, zu einer Ringzone sich vereinigten."

According to this interpretation therefore, Ruppia is descended from a form with four distinct main vascular bundles, traces of which are still apparent in the four phloem regions at the nodes; for here, as is generally admitted, ancestral characters are wont to appear.

Summary. The stem is composed of a thin walled epidermis; a loosely constructed cortex, containing as its principal feature a ring of radially arranged lacunae, and also two small bundles ending in the cortex—fibrovascular connections with the leaf sheaths; and a well defined endodermis, surrounding a very simple axial vascular region of a concentric structure, the appearance of which at the nodes indicates its reduction from four vascular bundles.

b. Rootstock.

The branching of the rootstock, or horizontal axis, as already stated, conforms strictly to the monopodial type, although torsion and the decay of the leaves often renders this obscure.

In its internal structure, as would be expected, it agrees with the stem (Pl. III, fig. 9). No points of difference were noted, except that sometimes the cells are somewhat larger than is customary in the upright axis, and often contain a large amount of starch.

The main differences between this and its morphological equivalent, the upright axis, are its horizontal position and the occurrence of roots at the nodes

3. Stem Structures in the Floral Region.

Three forms coming under the category of stem are found in connection with the production of flowers and fruit: (a) the peduncle, or the stalk of the inflorescence, (using this term in its narrower sense); (b) the rhachis or axis of the inflorescence, which is joined to the apex of the peduncle and bears the sessile flowers; (c) the stipe, a stalk which acquires its full development subsequent to the fertilization of the ovule and bears the mature fruit at some distance from the rhachis.

These three parts will be considered in order.

a. Peduncle.

(1) General Characters.

At the time of blooming the peduncle is short, about 2.5 cm., in length, and is raised nearly its whole length vertically above the surface of the water. About the time that the pollen is shed and the anthers fall off, the peduncle becomes horizontal, floating on the surface of the water. From now on it commences to elongate, presumably by simple stretching of its cells, as no meristematic regions were found to prove the contrary. It elongates until in some cases it attains great length. One specimen I measured was 18.2 cm. long. Elongation takes place whether fruit is matured or not, and the length is apparently just as great in either case. Indeed, the specimen just mentioned bore no fruit. The average length of the peduncle when no fruit was matured was 5.39 cm. The average length in 80 specimens when ovules were matured was 4.9 cm. On the whole, therefore, the average length of the extended peduncle is about 5 cm. or about twice that at the time of flowering.

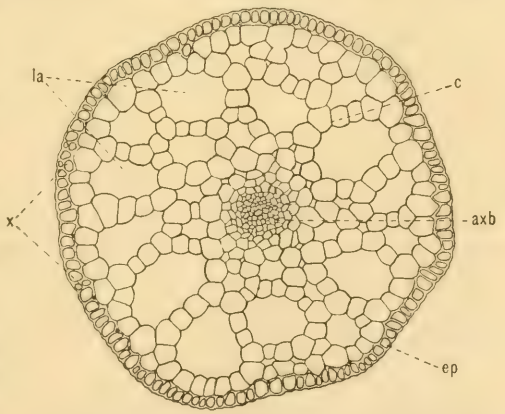


Figure 9.—Cross section of peduncle, showing at *x* the apparently double epidermal cells; *ep*, epidermis; *la*, lacunae; *c*, cortex; *axb*, axial bundle. × 185.

(2) Anatomical structure.

In general, the anatomical structure of the peduncle is very similar to that of the leafy stem (Text-fig. 9; Pl. VI, fig. 34). The following points, however, are noteworthy:—

1. As would be expected, no cortical leaf trace bundles are present.

2. The central vascular area is very similar to that of the stem. The tracheae in the center are pretty well disorganized, which is natural when one calls to mind the considerable extension of the peduncle.

3. The lacunae are more numerous and much larger in proportion to the diameter of the peduncle than in the stem (Text-fig. 9; Pl. VI, fig. 34).

4. In comparison with the stem the epidermis has slightly thicker walls, and small intercellular spaces may occur between it and the subjacent layer, an appearance which one never sees in cross sections of the stem (Text-fig. 10).

5. Occasionally some of the epidermal cells have a peculiar halved appearance, as if a periclinal wall divided an ordinary epidermal cell into two parts. This is due probably not to a division in the epidermal cell, but to the fact that a small subepidermal cell is wedged up close to a small epidermal cell (Text-fig. 10).

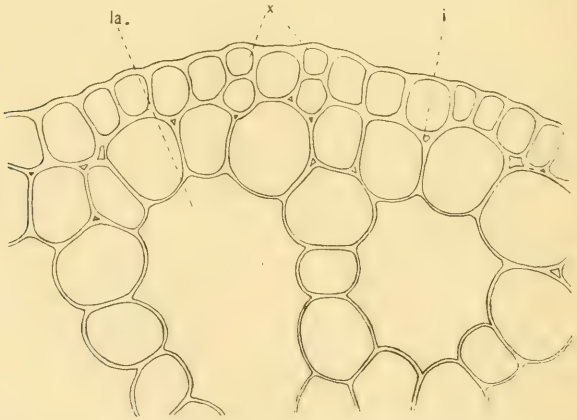


Figure 10.—Portion of cross section of peduncle; *x*, apparently double epidermal cells; *la*, lacunae; *i*, intercellular spaces. × 300.

On the whole, the main differences between this structure and that of the ordinary stem are its lack of cortical bundles and its lighter construction. The latter is explained when one recalls the fact that the peduncle for a great period of its existence floats, and hence its specific gravity must be small.

(3) Coiling of the peduncle.

Sooner or later the peduncle becomes spirally coiled, drawing the fruit, if any is matured, below the surface of the water. Some individuals exhibit this characteristic more markedly than others. Often, in fact, the peduncle is fairly straight. In case the coiling takes place, it is due to the cells on that side of the peduncle which will form the outer side of the spiral becoming longer than those on the inner side. This difference in length was ascertained in several specimens by actual measurement of the cells. Such curvatures as this occurring in plants are most often, as Strasburger (1908, p. 269) has explained, due in like manner to unequal growth.

b) Rhachis.

Here the internal structure is practically the same as in the peduncle. No appreciable elongation takes place as in the peduncle, and, therefore, the tracheae are not disorganized to such an extent. At the point of attachment of the stamens the rhachis is practically triangular in outline (Pl. III, fig. 11). The single axial vascular bundle sends a branch to each stamen and to each of the four pistils of a flower (Pl. III, fig. 12). This axial vascular region terminates with the branch sent to the uppermost stamen (Pl. III, fig. 12), the most distal member of the inflorescence, and does not therefore have a blind ending at the end of the rhachis.

The termination of the rhachis is simply a rounded knob (Pl. III, fig. 12).

All through the rhachis, in the interior as well as in the epidermal tissue, the "secretion" cells are abundant.

c) Stipe.

Although the pistils are termed sessile, and correctly so from a macroscopic standpoint, early in their development, before fertilization (Pl. III, fig. 12), considerable tissue is formed between the ovule and the rhachis by a region which remains meristematic for some time. At length the cell division ceases, and the cells stretch out, forming a stalk of considerable length, having at its end the mature fruit (Pl. IV, fig. 13). This stipal development is correlative; when no fruit is developed, the stipe is also wanting.

Pl. IV, fig. 14, which shows the secretion cells in the epidermis of the stipe, represents a stage when the cells are still quite young and short.

In its internal structure the stipe reveals no marked differences from the stem (Pl. IV, fig. 15). As in the peduncle, the cortical bundles are lacking. The lacunae are less pronounced than in the peduncle. The apparently halved epidermal cells occasionally appear.

and in places the subepidermal layer is thick-walled and constructed much like the epidermis (Pl. IV, fig. 16). As a whole, the structure shows greater strength than the peduncle.

4. Brief Comparative Study of the Stem Anatomy of the Potamogetonaceae.

Zannichellia (Campbell, 1897) and Althenia (Prillieux, 1864) perhaps most closely resemble Ruppia in their cauline structure, although they possess no cortical bundless. *Potamogeton pectinatus* (Schenck, 1886) also, which externally resembles Ruppia so closely, internally reveals a very similar stem anatomy. Moreover, the Potamogetons possess cortical bundles lacking in Zannichellia and Althenia. Cymodocea (Bornet, 1864), appears to differ mainly in having a thicker stem and a ring of small cortical bundles with lacunae between these and the axial vascular area.

In its vascular system Zostera (Sauvageau, 1891. I.) shows close relationship to Ruppia. *Z. capricorni* and *Z. nana* have one cortical bundle on opposite sides of the stem, as in Ruppia (Sauvageau, 1891). *Zostera marina* (Chrysler, 1907. p. 172, fig. 29) is also similar. In other species these bundles are more numerous. The bundles run free the whole length of the internode, unite with the central area at the node and send out branches which become the lateral nerves of the leaves. The central vascular area appears composed of four fibrovascular strands, the phloem parts isolated and separated, and the xylem bundles united into an axial strand.

Leaf

A. Enumeration of Kinds of Leaves

Of Strasburger's (1908, p. 26) four categories of leaves, three occur in Ruppia:—the scale leaves, small specialized structures at the base of every branch (Pl. II, fig. 6, *vsl*; Text-figs. 19–20, *vsl*, *fsl*); secondly, the ordinary long, narrow foliage leaves; and finally, the subfloral leaves, belonging properly to the category of bracts, a pair of which is borne at the base of the peduncle (Text-figs. 19–20, *up. sfl, low. sfl*). Since the flower is naked, there are no floral leaves.

B. Arrangement

An investigation of the position of the leaves throughout the plant reveals the following:

1. The general leaf arrangement is distichous (Pl. I, fig. 2; Pl. II, fig. 6), as in other members of the Potamogetonaceae so far as known, with the exception of *Potamogeton natans* and *Potamogeton lucens*, where a several ranked arrangement sometimes occurs (Irmisch, 1858 and Ascherson, 1889).

2. A single plane, therefore, will intersect all points of leaf insertion on any stem (Pl. I, fig. 1; Pl. VI, fig. 25).

3. Moreover, on all branches, this plane of leaf insertion coincides with that of the main stem, a feature which combines with the methods of branching to produce the characteristic flat, fan- or sickle-shaped plants, a condition already noted in the Potamogetonaceae by Ascherson (1889) (Pl. I, fig. 2; Pl. II, fig. 6).

4. The first, or basal leaf of every branch, which is in all cases a scale leaf, originates on that portion of the branch opposite to the subtending leaf—i. e., with its back toward the main axis of the shoot (Pl. II, fig. 6, *vsl*). No internode is placed between it and the subtending leaf, so that it is therefore exactly opposite the latter.[1]

5. The second leaf of every branch, in all cases a foliage leaf, is developed on the side of the branch adjacent to the subtending leaf, and thereafter ordinary foliage leaves of the branch proceed in regular distichous order (Pl. II, fig. 6, $l_1^{(I)}$, $l_2^{(I)}$, &c.).

In an account of the leaf of Ruppia I shall describe the three sorts of leaves, beginning with the ordinary foliage leaves, taking up next the subfloral leaves, and concluding with the scale leaves.

C. Ordinary Foliage Leaves

General Characters. The ordinary foliage leaves are "ribbon-shaped"; long (7—17 cm.), and very narrow, (about 1 mm.) (Pl. I, fig. 2; Pl. II, fig. 6). Although to the naked eye the margins appear entire, the microscope reveals at the apex a large number of one- to three-celled teeth, and these, with increasing distances between them, extend a considerable distance down the margins of the leaf (Pl. VI, fig. 26; Text-fig. 11). Upward from the base of the leaf, on each side, extending for 13–27 mm. are thin translucent appendages,

[1] Goebel (1898, pp. 68—69) says, however, in speaking of the phyllotaxy of axillary branches in general, that, due to mechanical causes in the bud, "die bei weitem häufigste Stellung der beiden ersten Blätter des Axillartriebs eine *laterale* ist, und erst die folgenden Blätter *median* oder mehr oder weniger schief gestellt sind."

which I have termed the stipular sheaths (Pl. I, fig. 2; Pl. II, fig. 6). In external appearance the leaves very closely resemble those of *Potamogeton filiformis* and *Potamogeton pectinatus*, both also typical submerged plants (Morong, 1893). The leaves of Zannichellia and Althenia are also macroscopically very similar: those of all species of Naias are much shorter with strongly serrate or toothed margins.[1]

Development of the Foliage Leaf. Different stages of leaf development are represented in Pl. I, fig. 1; Pl. VI, fig. 25, longitudinal sections of a vegetative bud, where the youngest leaf is the protuberance at one side of the growing point (L^{VIII} in Pl. I, fig. 1). The next older leaf primordium, shown on the right of the growing point (Pl. I, fig. 1, L^{VII}), has already slightly elongated, until now it extends beyond the growing point. Successively older stages are represented by L^{VI}, L^{V}, L^{IV}, &c.

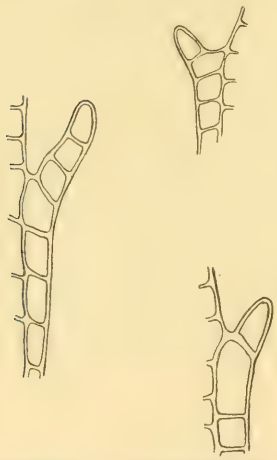


Figure 11.—The marginal leaf teeth, showing variation in cell arrangement. × 300.

Pl. VII, fig. 43 represents a transverse section through a similar bud cut through about the region of the line *a b* in Pl. I, fig. 1. Therefore, we find here the different members in exactly the same orientation as in Pl. I, fig. 1. Thus, the outermost leaf, L^{I}, embraces with its sheaths all the internal complex, just as is shown by L^{I} with its sheaths in Pl. I, fig. 1. The next inner member is $l_1^{(I)}$, or the lowest and largest foliage leaf of the axillary bud of L^{I}; then a section through the apical portion of the scale leaf which envelops this axillary bud; next the leaf sheaths of the next upper main leaf, L^{II}, appear, which brings us to a cross section of the central stem: without going into more detail it is sufficient to note that the remaining parts may be correlated to their corresponding longitudinal sections in the same way. The line *a b*

[1] All these species belong to Hansgirg's (1903) "Vallisneria-Typus der Strömungsblätter," a physiological group showing little differentiation into blade and petiole and characterized by the lack of cuticle, hair structures and stomata, by the absence of any considerable amount of supporting tissue, and by the ribbon-like, isolateral form.

in Pl. VII, fig. 43 represents the approximate plane in which a section similar to that in Pl. I, fig. 1 and Pl. VI, fig. 25 would be cut.

With the help of these sections and other similar serial preparations, I have found that the course of development and distribution of growth in the ordinary foliage leaf is approximately as follows: the leaf primordium first appears as a mere swelling at one side of the growing point, Pl. I, fig. 1, L^{VIII}; this protuberance soon differentiates into two parts, an "upper leaf," elongated in the direction of the growth of the shoot, and a "leaf base,"—to use the terms of Eichler, 1865—consisting of lateral protuberances on each side of the base of the "upper leaf" and extending part way around the shoot axis (Pl. VII, fig. 39). This arrangement is also shown, though not very clearly, by Pl. VI, fig. 28. The "upper leaf" will produce the leaf blade and the "leaf base" the leaf sheaths. The upper leaf now elongates rapidly, being composed entirely of embryonic tissue, and the succeeding stages are essentially those described by Prantl (1883): the cells at the apex are the first to commence extension to their mature size, and this stretching gradually proceeds toward the base of the leaf. The final developmental stage is marked by a considerable growth of the sheaths due to the intercalary growth of the leaf, which Goebel (1898, p. 518) states is so characteristic of monocotyledonous leaves.

A point of interest here is the comparative large size of the sheath rudiments at the first segmentation of the leaf primordium (Pl. VII, fig. 39), a circumstance which will be discussed below under the heading of the leaf sheath.

For purposes of further description, it is best to divide the leaf into two parts,—the blade and the sheaths, assuming the blade to be that part of the leaf from the sheaths to the apex (Pl. I, fig. 2; Pl. II, fig. 6).

1. The Leaf Blade.

A cross section of a leaf, made above the region of the sheaths, is represented in Pl. VII, fig. 43, $l_1^{(I)}$. An epidermis of comparatively narrow cells, a subepidermis of wider cells, a single axial vascular bundle with one subsidiary bundle running along each leaf margin, a lacuna or air space on each side of the axial bundle, and a few extra interior layers of parenchyma cells toward both edges of the leaf and surrounding the vascular bundle comprise, in brief, the internal structure of the leaf blade.

a. Epidermis.

(1) Chloroplasts.

An interesting point brought out by a study of the epidermis, and shown especially well in the living condition, is the fact that here most of the photosynthesis is carried on, for the cells contain large numbers of chloroplasts (Text-fig. 12). The discussion of the causes of this condition, being of an ecological nature, will be postponed for the present.

(2) Marginal Teeth.

The teeth, mentioned above, p. 88 (Pl. VI, fig. 26; Text-fig. 11), have already been observed in the leaves of *Ruppia maritima* by Sauvageau (1891, II, p. 209), who says, "à son sommet [i. e. of the blade] la plupart des cellules terminales se prolongent en dents arrondies composées de 1–2–3 cellules. Des dents semblables, mais plus espacées, se retrouvent sur les bords latéraux du limbe et font légèrement saillie." In a young stage, as in Pl. VII, fig. 39, the teeth appear mostly at the end of the leaf primordium; later they may be found down the margins of the leaf anywhere from $\frac{1}{2}$ to $\frac{3}{4}$ of the whole distance from the apex. Finally, in the adult leaf they rarely extend more than $\frac{1}{4}$ of the distance from the apex.

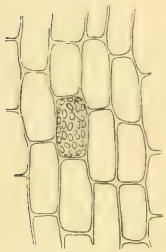


Figure 12.—Portion of epidermis of leaf, showing chloroplasts. Drawn from living leaf. × 335.

(3) Secretion Cells.

In the epidermis I have observed also the cells referred to by Sauvageau (1891, II, p. 209) as "cellules sécrétrices," containing, in alcoholic material, a granular or a homogeneous content of a brownish color, and somewhat larger than the ordinary epidermal cells (Pl. VI, fig. 30; Pl. III, fig. 8). They appear to be identical in nature with those of the stem. Although Sauvageau asserts that they are most abundant at the edges and at the apex of the leaf, yet they appear to me often to increase in numbers towards its base, including that part which adjoins the sheaths, as well as in the sheaths themselves (Pl. VI, fig. 25). According to Sauvageau these peculiar cells occur also in Posidonia, Cymodocea and Halodule. He has ascertained the presence in them of tannin, probably in combination. In my permanent slides their contents were almost invariably granular, assuming, with the triple stain, either a crimson or a brilliantly refracting yellow color—more often the latter. With ferric chloride the contents stained a brownish black and the same result was given on treatment with potassium bichromate.

These reactions confirm Sauvageau's assertion that these cells are tanniferous. As is well known, tannin is a common byproduct in plants, and in this case is possibly deposited in special cells on account of the difficulty of its diffusion through the epidermis. That these tanniferous cells should be more abundant toward the base of the leaf is natural, for it would be more economical for the plant to devote as many as possible of the cells in the upper part of the leaf to photosynthesis.

(4) Absence of Stomata.

Another peculiarity of the epidermis is the absence of stomata, which will be discussed later (p. 118).

b. Subepidermal Layer.

Below the epidermis, at all parts of the leaf, is a distinct layer one cell thick, which I have termed the subepidermal layer (Pl. VII, fig. 43), composed of cells about twice the width, tangentially, of those of the epidermis; and longitudinally, i. e. running the length of the leaf, many times longer than the epidermal cells (Text-fig. 13). This layer contains a few chloroplasts (cf. Sauvageau, 1891, II, p. 293).

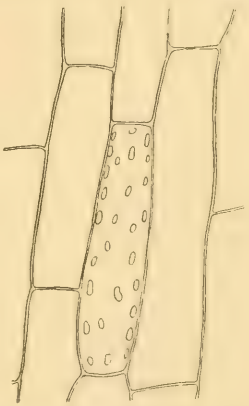


Figure 13.—Portion of subepidermal layer of leaf blade, showing a few chloroplasts. Drawn from longitudinal section cut from living leaf. × 335.

c. Vascular System.

The vascular system of the leaf is extremely simple. Three strands of conducting tissue are present—one large axial and two small marginal.

(1) Course of Vascular Bundles.

These three vascular strands enter the leaf separately at its insertion on the stem. The axial bundle maintains a median position and extends to very near the tip of the leaf (Pl. VI, figs. 26, 30; Pl. VII, fig. 43); the two lateral bundles enter one on each side of this axial bundle, and throughout their extent run parallel to it (Pl. VII, fig. 43, *lb*).

In the region of the sheaths each of these lateral bundles runs along the edges of the leaf proper, just at its line of junction with the sheaths, and above the leaf sheaths they retain this marginal position. I can confirm Sauvageau's (1891, II, p. 210) observation that they do not unite with the median bundle near the apex of the leaf, but disappear—according to my preparations, about 10 mm. from the apex.

(2) Structure of Vascular Bundles.

The axial bundle contains two or three annular tracheae in its young stage, which generally break down in the mature leaf to form an open passageway; surrounding this portion are phloem cells and parenchyma, difficult to distinguish on account of their low degree of differentiation, and about the whole axial bundle is a pretty definite endodermis, which Sauvageau has also noted. The structure of the two lateral bundles is extremely simple, consisting merely of a very few small conducting cells (Pl. VII, fig. 43, *l b*).

d. Lacunae.

On each side of the central bundle, separated from it by two or three layers of parenchyma, are the lacunae (Pl. VII, fig. 43, *l a*). In mature leaves these are of the shape of flattened cylinders, extending longitudinally through the leaf, and divided into compartments by transverse, sometimes oblique, perforated, one-layered plates of roundish cells (Pl. VI, fig. 25; Text-figs. 14–15). The perforations are round intercellular spaces, occurring regularly at the

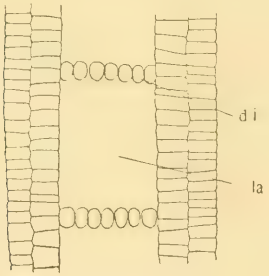


Figure 14.—Longitudinal section of lacuna, showing cross sections of diaphragms; *d i*, diaphragm; *l a*, lacuna. × 185.

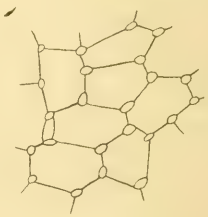


Fig. 15.—Surface view of one of the diaphragms which separate the leaf lacunae into compartments. The small circular outlines represent spaces between the cells. × 350.

angles of the cells and affording communication for the air or gases from one compartment to the next.

e. Comparison with Other Potamogetonaceae.

The anatomy of the leaf of *Potamogeton pectinatus*, a plant so much like Ruppia in external appearance, is almost a duplicate of the leaf structure of Ruppia (Schenck, 1886, p. 16 and figure 11 *d*). The other species of Potamogeton show differences more or less great, according to the shape of the leaf and the external conditions. The leaves of *Zannichellia palustris* (Schenck, l. c.) and *Althenia*

filiformis (Sauvageau, 1891, II, p. 259, and Prillieux, 1864) are very similar, the main difference being the absence in both of the marginal bundles, although Althenia has in place of these, small groups of fibrous cells. Althenia is, moreover, further distinguished by a rather large number of lacunae of various sizes.

The leaves of Zostera, Phyllospadix, Posidonia, Cymodocea and Halodule, show greater differences, of all of which, together with the remaining Potamogetonaceae, Sauvageau has made an excellent comparative study in his "Feuilles des monocotylédones aquatiques" (1891, II).

2. The Stipular Sheaths.

a. Structure.

At every node the leaf envelops the stem by means of basal sheaths composed of only two layers of cells. These cells lack chlorophyll and become very minute at the free edge of the sheath (Pl. I, fig. 2; Pl. VII, fig. 43, *s h s*).

b. Development.

I have already (p. 89) mentioned the fact that the development of the sheath rudiments in the young leaf primordium is quite marked. From the record of measurements (see Table p. 94) of the length of sheaths at different stages of leaf development there is manifested a certain periodicity in the growth of the sheath. Thus its percentage of the whole leaf length in a very early stage is high, as is shown in Nos. 1 and 2 and Pl. VII, fig. 39;[1] next, during the special growth of the leaf (see p. 89) this percentage noticeably decreases, in some cases to a very marked extent;[2] finally, due to the ultimate basal intercalary growth, the proportional size of the sheath again increases until in the mature leaf the proportional length of sheath to entire leaf averages about 1 to 6 (Table, Nos. 27–38).

Although, even by making considerable allowance for error, the data in the table are not at all uniform, as is natural, yet they do bring to light with no uncertainty the large comparative development of sheath both at the beginning and at the end of leaf growth.

c. Function.

That this periodicity in sheath development is related to the principal function of stipules, that of protection of younger parts,

[1] Such an early enlargement of sheath is mentioned by Van Tieghem (1898, pp. 250–251), who speaks of it as quite general.

[2] Possibly the very low percentages are results of environmental influence, e. g. position of leaf on shoot, surrounding leaf sheaths, &c.

TABLE
of
COMPARATIVE LENGTH OF SHEATH
IN THE VARIOUS STAGES OF LEAF DEVELOPMENT.

Description of specimen	No. of specimen	Length of entire leaf	Length of sheath	Approximate percent. of sheath to leaf length.
Dissected from living plant	1	.14 mm.	.0525 mm.	37.5 %
„ „ „ „	2	.341 „	.0875 „	25 6 „
From prepared slide	3	.586 „	.0875 „	14.9 „
.. .. ..	4	.735 „	.11 „	14.9 „
.. .. ..	5	.8137 „	.1487 „	18.2 „
.. .. ..	6	.8137 „	.1225 „	15. „
.. .. ..	7	.8575 „	.1575 „	18.3 „
.. .. ..	8	1.137 „	.096 „	8.4 „
Living specimen	9	1.382 „	.096 „	6.9 „
From prepared slide	10	1.41 „	.122 „	8.6 „
.. .. ..	11	1.47 „	.19 „	12.9 „
.. „ „	12	1.54 „	.11 „	7.1 „
„ „ „	13	1.80 „	.17 „	9.4 „
Living specimen	14	2.275 „	.262 „	11.5 „
From prepared slide	15	2.362 „	.227 „	9.6 „
„ „ „	16	2.458 „	.166 „	6.7 „
.. .. ..	17	3.745 „	.105 „	2.8 „
Living specimen	18	11.14 „	.315 „	2.8 „
.. ..	19	11.81 „	.525 „	4.4 „
.. ..	20	22. „	1. „	4.5 „
.. „	21	31. „	1. „	3.2 „
.. „	22	38.6 „	3.6 „	9.3 „
„ „	23	61.9 „	9. „	14.4 „
„ „	24	66.6 „	4.6 „	6.9 „
„ „	25	70.4 „	1.4 „	1.9 „
„ „	26	70.9 „	2.9 „	4. „
Living matured specimen	27	102. „	14. „	13.7 „
„ „ „	28	109. „	15. „	13.7 „
„ „ „	29	116. „	18. „	15.5 „
„ „ „	30	116. „	23. „	19.8 „
„ „ „	31	118. „	20. „	16.9 „
„ „ „	32	125. „	25. „	20. „
„ „ „	33	130. „	25. „	19.2 „
„ „ „	34	130. „	25. „	19.2 „
„ „ „	35	133. „	25. „	18.7 „
„ „ „	36	134. „	24. „	17.9 „
„ „ „	37	144. „	22. „	15 2 „
„ „ „	38	163. „	27. „	16.5 „

is well exemplified in the leaf sheaths of Ruppia. It is stated by Goebel (1898, p. 556) that no general rule can be given for the time of stipular development, but that as Massart (1894) had already emphasized before him, they are formed and called into play when their function is most needed, as is in fact true of other parts of the leaf (Goebel, 1898, p. 503). I shall undertake presently to show why the leaf sheaths may be considered stipular as to their nature and origin.

In Ruppia the delicate parts in the region of the growing point are in great need of the protective offices of the early developed sheaths of surrounding leaves; and also the mature leaves, since they almost always contain axillary buds, require large enveloping sheaths. These considerations may explain the manner of sheath development.

d. Morphological and Morphogenetic Considerations.

The nearly related genus Potamogeton throws considerable light upon the question of the morphology and morphogeny of the leaf sheath. This genus, as is well known, embraces a great variety of forms, from those with broad floating leaves only (or with the addition merely of capillary phyllodia), passing through intermediate forms which have both narrow submerged leaves and broad floating leaves, to the typical submerged plants with narrow leaves only. In the last group we find basal sheaths on the leaves of most of its representatives, e. g. *P. filiformis, P. pectinatus, P. interruptus,* &c; but in the broad leaved forms and in the intermediates we find no sheaths, free stipules, however, being more or less prominent.

It seems clear, then, that in the submerged forms sheaths replace the stipules; and this deduction is borne out by such a species as *P. diversifolius*, which has the *submerged* leaves with stipules sometimes adnate, and even better by *P. spirillus*, where the stipules are always adnate to the submerged leaves, while those of the floating leaves in both species are free.

A comparison of any of the above mentioned typical submerged Potamogetons with Ruppia—especially *P. pectinatus* and *P. filiformis* —shows the similarity of the sheaths in the two genera. One may conclude, then that both the free stipules of the Potamogetons and the sheathing stipules of the submerged forms and of Ruppia are closely related, being connected as they are by many gradations; and it is probable that the sheathing stipule has been evolved from the free stipule, such as it is in Potamogeton.

As to the reason why this form of stipules is developed in water plants, the most obvious explanation seems to be that joined to

the leaf-base they can better perform their office of protection of the axillary structures. In the case of the grasses, where the sheath is also retained, Strasburger (1908, pp. 29, 30) states that besides protecting the soft lower part of the internodes when intercalary growth takes place, the sheaths also give the stem rigidity. Possibly this latter strengthening function applies also in some degree to the sheaths of water plants.

3. Axillary Scales.

a. General Characters and Anatomy.

In the axils of all the leaves are two small, ovate, scaly formations, one on each side of the median line of the leaf (Pl. III, fig. 8; Pl. VII, fig. 43, *a s*). These structures, common in water plants, and first shown by Irmisch (1858, p. 12) to be of general occurrence throughout the Potamogetonaceae, consist of generally two layers of cells rounded in cross-section, and loosely joined together, containing large nuclei and a large quantity of cytoplasm (Text-fig. 17). A longitudinal section of a single scale (Text-fig. 16), shows that

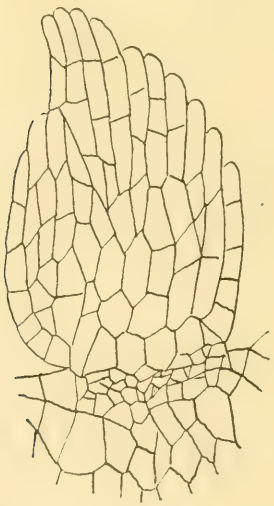


Figure 16.—Longitudinal section through axillary scale, showing arrangement and shape of cells. × 170.

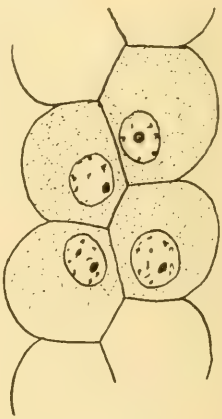


Figure 17.—Cells from cross section through axillary scale, showing cell structure. × 1400.

these cells are long and arranged more or less in rows in the upper part of the scale. Prillieux (1864) has found similar struc-

tures in *Althenia filiformis*, which he erroneously believed to be stipules.

b. Function.

The nature of these "*squamulae intravaginales*" points to their serving the purpose of secreting organs. Schenck (1886, p. 9) is of the opinion that their secretion, which covers the growing point, is a protection against parasites, but of this point he is not certain. F. Müller (1877) had already claimed that the slimy secretions of such cells protected the delicate growing points from immediate contact with the surrounding water, a position which Schenck (1886, p. 10) criticizes by asserting that it is difficult to see how the outside water could injure the growing points. But Schilling (1894), who has made a special study of the subject, returns to Müller's view. He shows that the slime is impermeable to certain salts, &c. in solution in the water, and is probably only developed until the epidermal tissue and cuticle are far enough advanced to make such protection unnecessary.

Schilling's arguments are reasonable. The growing point is an extremely delicate part and might easily be injured by the salts or other substances in solution in the surrounding water. Especially is this true of Ruppia, a plant of salt or brackish waters. This would be an omnipresent danger to the young growing parts: the attacks from parasites would be intermittent or rare.

D. Subfloral Leaves

Although along the stem the leaves are distributed at fairly regular intervals, just below a flower they approach each other so closely as to appear opposite (Pl. VII, fig. 35; Text-fig. 18), a characteristic common to many other members of the family, notably Zannichellia, Althenia, Potamogeton, &c.

These two apparently opposite leaves, which I have designated the subfloral leaves, besides differing from the ordinary foliage leaves in their mode of arrangement, possess slightly specialized sheaths and considerably shorter leaf blades. The sheath of the outer or lower leaf envelopes that of the inner, while the sheath of the inner or upper leaf surrounds the peduncle, and both together form a protective envelope for the young flower before it elongates (Pl. II, fig. 6; Pl. VII, fig. 35). As a result of these conditions, the sheaths are slightly wider than those of the ordinary leaves, and they as well as the leaf blades are also shorter, the latter characteristic being in harmony with the bracteal nature of these leaves.

In all other respects, however—internal structure, axillary scales, &c.—the subfloral leaves are identical with the ordinary foliage leaves.

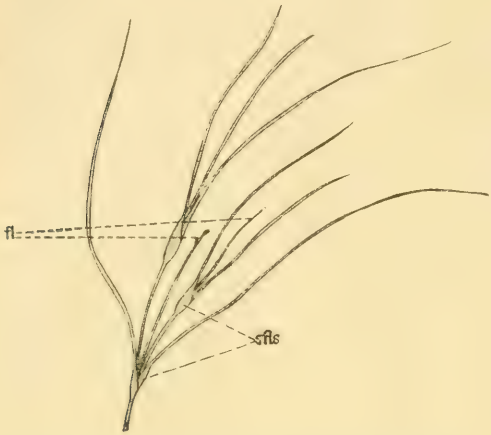


Figure 18.—Sketch of flowering branch, showing location of flowers and subfloral leaves. ½ natural size.

Koch and Irmisch have called these two leaves "folia floralia," an unwieldy term, whose English equivalent is at present applied to the modified leaves forming the floral envelope in the Phanerogams. On account of their position near the peduncle and their slight modification in form, they approach the category of "bracteal leaves" or "Hochblätter" of Strasburger (1908, p. 31) and Goebel (1898, p. 578), yet the difference from the ordinary leaves is so slight that such a classification seems unwarrantable. I have therefore adopted the term "subfloral leaves," although bearing in mind their approach to typical bracts.

E. Scale Leaves

Besides the subfloral leaves and ordinary foliage leaves, two other sorts of leaf structures occur in *Ruppia maritima*, quite similar in appearance and structure. These are very small membranous formations—one kind borne at the base of the ordinary branches and the other at the base of the floral axis (Pl. I, fig. 1; Pl. II, fig. 6, *vsl*; Text-figs. 19–20, *vsl* and *fsl*). The first sort is plainly what Goebel (1898, p. 572) has in mind when he writes of "Vorblätter." He says, "Die Vorblätter sind zunächst charakterisiert durch ihre Stellung. Wir finden sie—wo sie überhaupt vorkommen—bei den Dikotylen meist in Zweizahl an der Basis der Seitensprosse, bei den Monokotylen wird gewöhnlich ein Vorblatt angenommen, welches auf der dem Muttersprosse zugekehrten Seite des Tochtersprosses steht."

Strasburger (1908, p. 429) also mentions "Vorblätter," but with him they signify bracts or bracteal leaves. It is his category "Niederblätter" or "scale leaves" that includes the structures described by Goebel as "Vorblätter."

In accordance with the Bonn Textbook I have adopted the term scale leaf: the leaf at the base of the ordinary branch will be referred to as the vegetative scale leaf, while that at the base of the peduncle will be termed the floral scale leaf.

1. The Vegetative Scale Leaf.

a. General Characters.

This envelops the base of all axillary structures, except that in the axil of the upper subfloral leaf, and is developed on the side of the axillary member opposite to that of the subtending leaf. Flattened out, it is in the form of a long narrow triangle (Pl. VII, fig. 40), from 6 to 13 mm. in length; in position, its edges slightly overlap at the base, on the side nearest the subtending leaf (Text-figs. 19–20). If the axillary members are young, it completely envelops them; when they grow out, forming a branch, it remains sheathing the base of the branch.

b. Internal Structure.

Anatomically the vegetative scale leaf is composed of two layers of elongated large-vacuolate cells, rectangular in outline, with the nucleus flattened against the wall, and with a very few small chloroplasts. No vascular bundles are present. Pl. III, fig. 8 and Pl. VII, fig. 43, *vsl* show a transverse section, and Pl. VII, fig. 37 a surface view.

2. The Floral Scale Leaf.

a. General Characters and Structure.

The other form of scale leaf, which I have termed the floral scale leaf, occurs always at the base of the peduncle, on the side toward the youngest or upper subfloral leaf (pp. 97–98 and Text-fig. 20, *fsl*) and its base is coincident with the base of the floral axis for nearly one half of its circumference. Its development can be easily traced in Pl. IX, figs. 54, 55, 56, 51 and Pl. VII, Fig. 41, *fsl*, and it will be seen that never at any time does it completely envelop the floral axis, as does the scale leaf the base of the axillary shoot, but nevertheless partly surrounds it. When the peduncle elongates in the course of floral development, the floral scale leaf remains at its base, similarly as in the case of the vegetative scale leaf. Moreover, in its growth this scale leaf follows the growth of the flower and is entirely in independence of the adjacent axillary bud.[1] (Pl. VII, fig. 41, *fsl*).

[1] I have been unable to find a flower bud in which there was no branch in the axil of the upper subfloral leaf, which would of course, be an

In shape the floral scale leaf differs considerably from the vegetative scale leaf. It is shorter, almost symmetrically oblong and emarginate (Pl. VII, fig. 42; Text-fig. 19, *fsl*).

The internal structure is identical with that of the vegetative scale leaf.

3. Orientation of Scale Leaves in Floral Region.

The plan of a typical arrangement in the floral region is represented in Text-figs. 19–20. Here we find the members occurring in the following order, proceeding from right to left:—

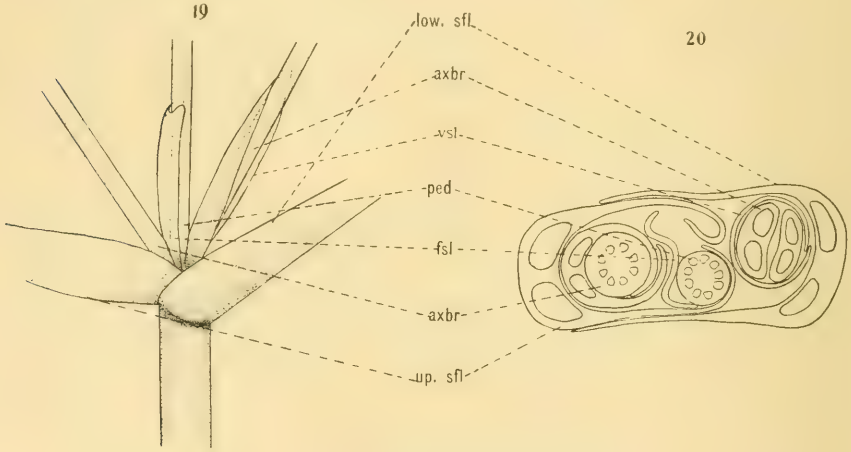


Figure 19.—Portion of the plant near the floral region, showing the two kinds of scale leaves and the subfloral leaves. The parts are somewhat separated so that they may be seen more clearly. *low. sfl.* lower subfloral leaf; *axbr*, axillary branch; *vsl*, vegetative scale leaf; *ped*, peduncle; *fsl*, floral scale leaf; *up. sfl*, upper subfloral leaf. × 6.

Figure 20.—Cross section through flower bud, below flowers, showing parts represented in figure 19. Abbreviations as in figure 19. × 35.

1. The lower subfloral leaf (*low, sfl*). sheathing the entire flower bud;
2. The branch (*axbr*), arising in the axil of this leaf;
3. The vegetative scale leaf (*vsl*), enveloping this axillary structure and borne at its base on the side furthest removed from the subtending subfloral leaf;
4. The peduncle (*ped*), bearing the flowers;

---

exception to the general rule. If such cases could be found, showing a normal floral scale leaf, this would prove that the scale leaf is borne on the peduncle and not on the axillary bract.

5. The floral scale leaf (*fsl*), adherent to the base of the peduncle in a position corresponding to that of the vegetative scale leaf;

6. The branch (*axbr*), arising in the axil of the upper subfloral leaf;

7. The upper subfloral leaf (*up. sfl*).[1]

4. Summary of Distinguishing Characters.

Irmisch (1851) has described the inflorescence in *Ruppia rostellata*. His account is in part as follows: "Die folia floralia bilden nun zwei Achseln, aus denen Zweige hervorbrechen, welche sich folgendermassen verhalten. Das erste tief an der Basis der Zweige stehende Blattgebilde ist eine dünnhäutige abgestutzte lanzettliche Schuppe, die sich um den Grund des Zweiges herumlegt. Ich will sie Vorblatt nennen. Es steht dasselbe, wie das auch sonst regelmässig der Fall ist, mit seiner Rückseite wegwärts vom Mutterblatte des Zweiges und dem Blütenstande A zugewendet";—and further, "Der Zweig in der Achsel des obern fol. flor. ist dem des untern in der äussern Bildung gleich."

In this and his description following, it is clearly evident that Irmisch considered the floral scale leaf and the vegetative scale leaf in an inflorescence to be identical, for he alludes to nothing but a vegetative scale leaf (Vorblatt) at the base of each branch. Of course it is possible that no floral scale leaf, as such, occurs in *Ruppia rostellata*, yet the two species are evidently quite similar. For example, Sauvageau (1891. II) finds no differences in the structure of their foliage leaves.

To sum up the differences between floral and vegetative scale leaves, they are in brief as follows.

1. Shape. The floral scale leaf differs markedly in shape from the vegetative scale leaf. A large number of specimens was examined and this difference was constant.

2. Position. As shown in Text-fig. 20, but more clearly were the section cut at a lower plane, the floral scale leaf does not envelop the axillary shoot as does the vegetative, but is turned toward and partially surrounds the young flower or the peduncle, according to the stage of floral development.

3. Development. The growth of the floral scale leaf is always correlated with the growth of the peduncle and flower—even when the axillary structure adjacent is as yet rudimentary. In case the

[1] The axillary scales have been purposely omitted. The cross section represented in Text-fig. 20 was cut above them.

floral axis is already well developed, one finds a correspondingly advanced development in the floral scale leaf, showing that it is now connected with and influenced by the flower and peduncle.

5. Morphological and Physiological Nature of Scale Leaves.

That the vegetative scale leaf is a leaf and not an axillary stipule, may be accepted without question, for its development occurs much later than that of the subtending leaf and its origin is from the axillary bud of the latter. As to whether one has to deal here with a degenerate leaf, or one that approximates the primitive form is a question difficult to settle without a definite knowledge of the primitive monocotyledonous leaf form. It is probable, however, that the ordinary foliage leaves are nearer to the primitive form. Moreover, the lack of vascular tissue and chlorophyll, and the simple structure in general indicate a degenerate form.

Whatever its genetic origin, the early development and complete enfolding of the young primordia, which later grow out beyond it, point to the present function of the vegetative scale leaf as being essentially protective.

The nature of the floral scale leaf is not so clear. The striking fact, however, that the branch adjacent to this scale leaf never has a vegetative scale leaf at its base would seem to point to the conclusion that the floral scale leaf is simply this vegetative scale leaf now connected with the flower and utilized for its protection in an embryonic state.

6. Comparison with Other Potamogetonaceae.

Scale leaves (prefeuilles) are found in Althenia (Prillieux, 1864) where there are often two on a branch below the first ordinary foliage leaf. They occur also in Zannichellia (Irmisch, 1858, p. 30) and Cymodocea (Bornet, 1864). In Potamogeton (Irmisch, 1858) the scale leaves are quite abundant, occurring on the rootstock as well as at the base of the shoots. The prophyllon, or fore-leaf, described by Holm (1905) in his writings on the grasses, is an homologous structure.

Root

A. General Characters

The roots in Ruppia, as in many submerged plants, are simple, and strikingly reduced in structure. The primary root, formed

in the embryo, does not persist; the sole representatives of the root system are small slender adventitious roots arising at the nodes (Pl. VII, fig. 36, *r*). These occur singly or rarely in pairs and are unbranched. Each root, in the early stages of its development, is surrounded by a sort of pocket formed from the secondary growth of the epidermis of the stem. After the root has broken through the tip of this pocket, the latter remains as a persistent sheath or collar at its base. A zone of root hairs appears on every root, developed from specialized piliferous cells (Textfig. 21, *rh*).

As to the length of the root, I have measured specimens 20 cm. long, but a much shorter length is the general rule.

The life of the root is comparatively short; for as the stem advances in its growth, new roots are successively put forth from new nodes, the older roots becoming gradually discolored and ultimately dead, together with the stem or rootstock whence they originate.

Figure 21.—Sketch of portion of rootstock and root; *col*, coleorrhiza; *rh*, root hairs; *rs*, rootstock. × about 1½.

B. Root Arrangement

Since the laws of the root arrangement in Ruppia are often obscure, as regards both the roots themselves and also their orientation with respect to the leaves, a somewhat more detailed description than that already given seems necessary.

Irmisch (1858, pp. 44–45) has described at some length the relation of root to leaf arrangement in *Ruppia rostellata*, and for a more detailed account I would refer to him. The following is to some extent a confirmation of his observations as referred to *Ruppia maritima.*

The root is developed at the node, at one side of the leafbase, and in the comparatively rare cases where a second root is developed at the same node (Pl. III, fig. 10), it assumes a corresponding position at the other side of the leaf base.

Since the roots, when occurring singly, invariably issue from the same side of the stem, and since their orientation with respect to the leaf of the node is as just stated, the following facts or laws of arrangement are established:—

1. The line connecting the points of insertion of the roots is straight, provided the stem has undergone no torsion (Text-fig. 22).

2. On account of the alternate arrangement of the leaves, the roots appear at successive nodes on opposite sides of the median longitudinal plane of the leaf,—i. e., if at one side of the leaf at any node, then at the other side of the leaf at the next higher or lower node (Text-fig. 22).

These simple rules of arrangement are, however, not often apparent. In a great many instances the stems to a considerable extent, due probably to currents of water, light conditions, &c., become twisted.

In such cases the orientat ionof the roots with regard to the leaves remains nevertheless constant, in accordance with the rule stated in (2). In other words, no matter what position the leaves may assume on the stem, the roots always emerge, in any two successive nodes, at one side of the leaf at one node, and at the other side of the leaf at the next node.

Compared with the other Potamogetonaceae, Ruppia has perhaps the simplest root system, if one considers the number of roots alone. Zannichellia (Campbell, 1897, p. 40), with generally two slender, unbranched rootlets at each node, and Althenia (Prillieux, 1864, p. 182) with two or sometimes more, borne on alternate nodes, most resemble it. The roots of Cymodocea (Bornet, 1864) are often borne singly, but differ in being branched. The roots of many Potamogetons (Irmisch, 1858) are more numerous, arising often in a circular line of insertion at the nodes. In Zostera (Grönland, 1851) and Phyllospadix (Dudley, 1893) a cluster of roots occurs at each node.

C. Anatomical Structure

1. The Coleorrhiza.

Extending for a distance of often 5 mm. on the root from its junction with the stem is a peculiar sheath-like structure, termed by Irmisch (1858) the "coleorrhiza" or root sheath (Pl. VII, fig. 38; Pl. VIII, fig. 45, Text-fig. 21). Beyond mentioning the fact that it occurs in *Potamogeton crispus, Zannichellia palustris* and *Ruppia rostellata*, Irmisch gives no description of it. In the related plants which Prillieux (1864), Magnus (1870), Schenck, (1886), Campbell (1897), and others describe, no mention is made of such a structure. Sauvageau (1889) indeed merely mentions a coleorrhiza as appearing in Zostera. Bornet (1864) notes in Cymodocea the formation of a

sheath "more or less short" at the base of the root, but does not give a detailed account of it, so that its nature is not entirely clear. This is, however, probably a coleorrhiza.

According to Sachs (1875, p. 143) in grasses and some other Phanerogams, the first root arises so deep in the interior of the embryonal substance that in the fully developed embryo of the ripe seed it is enclosed by a thick, sac-like layer of tissue, which is ruptured on germination and is known by the name of "root sheath (coleorrhiza)." Similar formations occur also in the first secondary roots of the germinating plants of *Allium cepa*, and occasionally elsewhere.

Figure 22.—Diagrammatic representation of root arrangement; *r*, root; *L*, leaf.

The coleorrhiza[1] in Ruppia, which is found on all the adventitious roots, is of entirely different nature. Its development can be observed at all the early stages of the growth of the root. The first indication of it appears during the origin of the young root within the stem. As the young root develops and appears in the stem cortex, a change in character takes place in certain of the epidermal cells of the stem, and in a few in the subepidermal layers, which lie in the region whence the root would naturally emerge. These cells become filled with protoplasm, their nuclei enlarge, and cell division takes place, the resulting cells being small and narrow (Pl. III, fig. 10; Pl. VI, fig. 31; Pl. VIII, fig. 44). In other words, a new growth starts up in the epidermis and a few of the cells of the subjacent layer, but principally in the epidermal cells. This stage is, of course, the most important for the proof of an entirely independent correlative origin of the coleorrhiza.

As the root grows out from the node, the epidermal or coleorrhizal cells divide by anticlinal walls, keeping pace with the root growth for some time, and forming the pocket or enveloping sheath already mentioned.

---

[1] Since the term "root sheath" may be applied to several sorts of structures, it lacks definiteness. The subject of the present account, however, has a distinct character, as will be demonstrated more fully below, so that it seems fitting to apply the name coleorrhiza to it.

A cross section of the coleorrhiza as represented in Text-fig. 23 shows that it is composed principally of a single cell-layer. The section was cut purposely near the junction of root with stem, in order to show how toward the proximal end of the coleorrhiza a few of the cells of the subepidermal layer enter into its composition.

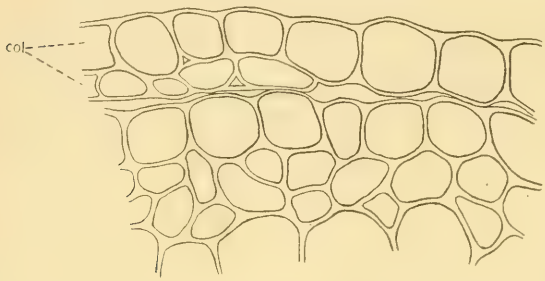


Figure 23.—Portion of cross section of root showing surrounding coleorrhizal layer. × 400.

As is shown by longitudinal sections, the cells in the outer or more distal region of this subjacent layer are undoubtedly the results of divisions similar to those which take place in the epidermal or coleorrhizal layer, but at the proximal or basal part of this subjacent layer the cells are larger and two or three rows deep, and those immediately adjacent to the root are considerably flattened. In this region, therefore, the subepidermal layers of the coleorrhiza are derived immediately from the cells of the stem without division, being forced outward by the development of the root and coleorrhiza.

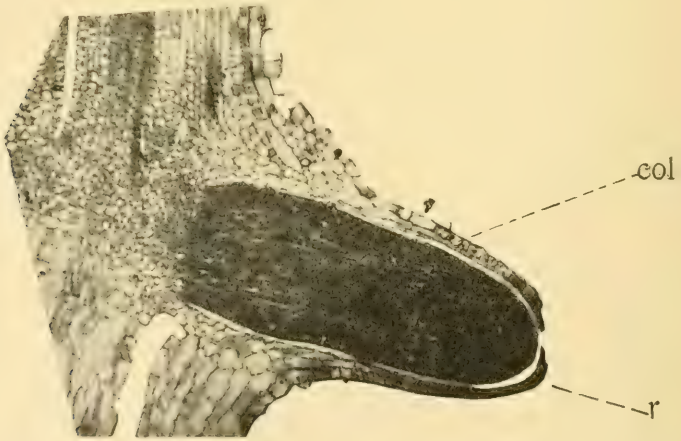


Figure 24.—Photomicrograph of longitudinal section of young root still enclosed in coleorrhiza; *col*, coleorrhiza; *r*, root. × 50.

Pl. VII, fig. 38 shows a well advanced stage, where by pressing with the cover glass the root was detached from its connection

with the stem and squeezed out of the coleorrhiza, producing the ruptured end of the latter. In this figure the coleorrhiza had attained approximately its maximum development. It then, with its enclosed root, appears to the naked eye as a small, smooth, blunt projection at the node. A photograph of a longitudinal section of this stage is shown in Text-fig. 24.

In the course of its growth the young root breaks through the coleorrhiza, which then remains at its base as a collar-like structure (Pl. VIII, fig. 45; Text-fig. 21).

An interesting incidental point in relation to the coleorrhiza, and one which indeed may be connected with its function, is the occurrence in its surface layer (when of more than one layer in thickness) of cells which are evidently secretion cells (Text-fig. 25).

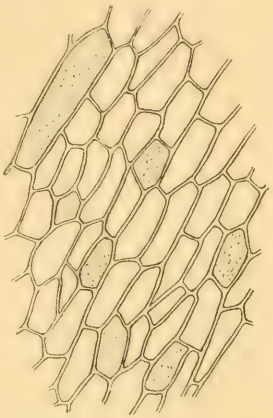


Figure 25.—Group of cells from surface of coleorrhiza, showing secretion cells. × 185.

It will be seen from the above description of the coleorrhiza in Ruppia that it is of entirely different nature from that to which Sachs (1875, l. c.) alludes. It has an external origin, being the outgrowth of the epidermis (including part of the immediately subjacent region) of that part of the stem which is situated over a developing root.

Such a structure as this evidently falls into the category of "correlative" growths. Having no immediate organic connection with the root and yet taking its inception close on the development of that organ, the nature of its growth is analogous, for example, to the correlative growth manifested in the development of fruit and fruit-covering after fertilization of the egg cell and during the development of the embryo.

As to the function of the coleorrhiza in Ruppia, not much can be said with any certainty. Perhaps it acts as an organ of protection for the root until the latter attains some length. The facts that it occurs only in water plants, so far as known; and that also, borne on it, are abundant secretion cells, may point to a functional secretion of slime of some sort to protect the young root in the water. Goebel (1893, pp. 233–237) has noted this quite general production of slime and slime-producing organs in water plants and has explained in some detail its beneficial effects. It has already been

noted that the axillary scales probably serve a similar purpose of protection for the young growing points of the stem.

The references in literature to a similar root sheath or coleorrhiza are scanty. As stated above, Irmisch gives it a mere mention in his work, as occurring in Potamogeton, Ruppia and Zannichellia. A similar formation in Lemna is described by Caldwell (1899). Long ago Strasburger (1873) noted and described an epidermal root sheath in Azolla. According to him the sheath was formed of two layers of cells, the inner layer eventually disorganizing and leaving the root free inside the sheath, which itself surrounded the root during its entire existence. Leavitt (1902), however, finds only one layer producing the sheath in Azolla, and through this the root soon pierces, leaving it as a collar at its base. Quite recently Lachmann (1906) has described an essentially similar structure in *Ceratopteris thalictroides*.[1]

2. The Growing Point of the Root.

Four meristematic layers appear well defined at the root tip (Pl. VI, fig. 31; Pl. VIII, fig. 44). The calyptrogen is a well marked region with several rows of tabular cells. The dermatogen layer, one cell thick, encloses all of the remainder of the meristematic tissue of the root. This dermatogen layer is continous, even at the apex. Inside of the dermatogen layer the periblem rows converge until they meet at the apex in a small cell area one or often two cells deep. At this same area the plerome originates, and the sides of the plerome cylinder are generally clearly marked off from the surrounding periblem.

Miss Daisy G. Scott (1906) in a recent paper has published the results of her investigations of the root tips of several aquatic monocotyledons. Among these are Ruppia, Naias and Zostera, in all of which the periblem and dermatogen arise from a single initial cell. These contain, then, according to Miss Scott, three apical meristematic regions, giving rise, the first to calyptrogen, the second to dermatogen and periblem together, and the last to plerome.

As will readily be seen, this arrangement disagrees with what I have described for Ruppia. Four meristematic regions are always clearly defined here. The dermatogen is invariably a continuous single layer, and the periblem arises quite often from a two-layered region at the apex, always showing at least one layer (Pl. VIII, fig. 44).

[1] Cf. also Goebel, 1898, pp. 469—470.

A four-layered type has indeed been known to be unusual since De Bary's (1884, p. 9) work, in which he describes it as appearing in only two plants, Pistia and Hydrocharis. Recently Campbell (1897, p. 40) has added Zannichellia to this list.

Beyond the papers of Miss Scott and Campbell, I find no record of other investigation on the apical meristem of the root tips of the Potamogetonaceae, if we except *Potamogeton crispus* and *natans*, studied by Treub (1876) and Flahault (1878), who assign to them three meristematic layers.

Considerable doubt and uncertainty have arisen concerning the tissue-forming capabilities of the various meristematic tissues of the growing point, a subject on which Scott (1894) has written an admirable resumé. Histogenesis in the roots of Ruppia is, however, perfectly clear. The plerome can be traced in its development into the central cylinder, communicating with the central cylinder of the stem. Thus, Pl. VIII, fig. 44 shows a plerome cylinder connecting

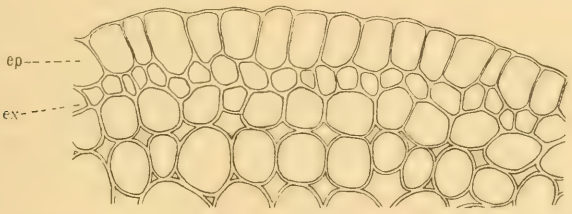


Figure 26.—Cells from outer part of cross section of root; *ep*, epidermis, *ex*, exodermis. Showing also two or three layers of cortex with intercellular spaces. ×325.

with the central cylinder of the stem. The width of this plerome at its base is about eight cells, which corresponds to the number of cells in the diameter of the central cylinder of the mature root—i. e., 7—10 (Pl. VIII, fig. 46).

3. The Anatomy of the Mature Root.

The internal structure of the root is even simpler than that of the stem. It consists of an epidermal region and a large zone of cortical parenchyma limited on the inside by the endodermis which surrounds the axial vascular bundle (Pl. VI, fig. 27). Each of these four parts will now be described in detail.

a. Epidermal Region.

The epidermis is a layer of large, thin-walled cells (Text-fig. 26), some of which produce the root hairs, to be described in detail presently. Beneath the epidermis, but not connected with it genetically,

is a layer of small, thick-walled cells, lacking intercellular spaces —evidently a strengthening layer (Text-fig. 26, *ex*). This may be designated the epidermoidal layer, as described by Juel (1884), or exodermis, as defined by Vines (1898, p. 111) and Strasburger (1908, p. 102).

(1) The Root Hairs. In a recent paper, Leavitt (1904) has published the results of his investigations on the root hairs of the higher plants, a subject which has hitherto been much neglected and concerning which only scattering references can be found here and there in the literature.

Leavitt has ascertained that the root hairs are of two types, depending on their manner of development. The first type may arise from any ordinary epidermal cell. The second type of trichome, common to most monocotyledons, arises from a specialized cell, which, in its embryonic state, Leavitt has termed a trichoblast.

It is to this second type that, as briefly noted by Leavitt, (1904, p. 292) *Ruppia maritima* belongs. According to my investigations, the root hairs arise here in the following manner. At a short distance back of the growing point, certain of the epidermal cells begin to differentiate. They are easily distinguished by their deeply staining, granular contents, and their larger nuclei, (Pl. VI, figs. 29, 32, 33). As to their size, there is some variation, but on the whole they are of about the same size as the ordinary epidermal cells. These peculiar cells are the primordia of the trichomes, called the trichoblasts, which by the subsequent development of tube-like projections from their free walls will produce the root hairs (Pl. IX, fig. 48).

As to their mode of origin, there seems to be no regularity. Often two or three non-piliferous cells alternate with the trichoblasts, but again, as many as a dozen or more ordinary cells may occur between two trichoblasts (Pl. VI, figs. 29, 32, 33).

Not all of the trichoblasts develop root hairs. They may remain simply as large cells with granular contents and large nuclei. They are evidently, then, as Leavitt has also noted, potential trichomes, the development of root hairs depending possibly on some stimulus. This explains why we find zones, often at considerable distances apart, where the hairs are developed in abundance.

A remarkable characteristic of the root hairs is their persistency. In roots which measured over 20 cm. in length, quite a number of hairs were noted still intact and apparently functioning even at the base of the root near the coleorrhiza. This condition is very common and may be due to the fact that the hairs are not worn off easily in the soft mud. Often, however, hairs do not

persist in this way—becoming broken off. Their basal parts then appear as blackened dead cells in the epidermis.

Leavitt (1904, p. 279) lays considerable stress on the small size in general of the trichoblasts and bases of trichomes as compared with the ordinary epidermal cells. In Ruppia, while some of the trichoblasts and bases of mature trichomes may occasionally be somewhat shorter, on the whole they average about the same size as the non-piliferous cells, even from the very first appearance of the trichoblasts (Pl. VI, figs. 29, 32, 33). In her paper on root hairs, Miss Snow (1905), from the study of several species, assigns no definite length to the hair-producing cells, but announces that in the same root the average length of the trichome-cells is less than that of the atrichomic cells.

b. Cortex.

Although to the cortex proper belong genetically the exodermis described above under the head of epidermal tissue, the cortical parenchyma, and the endodermis, I am describing each separately. Varying with the thickness of the root, from six to twelve concentric rings of large, rounded, thin-walled cells with diamond-shaped, schizogenous intercellular spaces, form the cortical parenchyma (Pl. VI, fig. 27). Often, in the mature root, on account of the radial expansion of the tissues, these parenchyma cells undergo a stretching, and separate from each other laterally, producing long strings of collapsed cells.

A longitudinal section proves that the intercellular spaces of the cortical parenchyma in the region of the endodermis, are often of a somewhat peculiar nature (Pl. VIII, fig. 47, *u*). These spaces arise by a local splitting of the wall, the split parts curving outward in opposite directions, forming openings which in the longitudinal section appear from spindle-shaped to circular in outline. These spaces may occur in series or singly at intervals. Near the endodermis they are small, increasing in size in the direction of the middle cortex. Before we come to the middle cortex, however, we find them elongated into long narrow canals, of which the diamond-shaped spaces described above are cross-sections.

c. Endodermis.

A single—occasionally, in places, double—ring of cells surrounding the vascular bundle, comprises the endodermis (Pl. VIII, fig. 46). Its radial walls show to a very slight degree the typical endodermal thickenings. The tangential walls are minutely wavy at irregular intervals. After treatment of cross-sections of the root with concentrated sulphuric acid, the endodermis as well as the epidermis and exodermis remain clearly defined.

d. Vascular System.

This is represented by a single vascular bundle in the center of the root, with a structure similar to that of the stem (Pl. VI, fig. 27; Pl. VIII, figs. 46, 47). No longer a typical radial root bundle, its present concentric structure admits of the same interpretation as regards adaptation as does the simplified bundle of the stem (see pp. 81–82). It differs from the stem bundle in only a few minor details. Barely as large as that of the stem, in all cases observed the root bundle retains intact the axial vascular area composed of a few tracheae. These tracheae are peculiar in that they possess no thickenings of any sort. Their walls, although extremely thin, can be distinctly seen in cross and longitudinal sections (Pl. VIII, figs. 46, 47, *tra*). Schenck has observed a similar peculiarity in the root of *Potamogeton densus*. He says (1886, p. 61), "Die Gefäße aber erfahren keine deutliche Differenzierung der Wandung; auf Längsschnitten sieht man keine Verdickungen oder nur schwache Spuren, so daß die Gefäße als Gänge erscheinen. Überhaupt erfahren in den Wurzeln der monocotylen submersen Gewächse die Gefäße, obwohl sie überall sofort zu erkennen sind, keine weitgehende Ausbildung. Die Resorption der Querwände tritt meist ein, bevor Verdickungen angelegt werden."

Five or six sieve tubes, with their companion cells, are situated at more or less regular intervals just inside the endodermis, forming an irregular ring. These can be distinguished in cross-section by their generally larger, nearly empty cell-cavities, their position just inside the endodermis, and their accompanying companion cells. In longitudinal section the sieve plates may be seen, as also the accompanying companion cells with their protoplasmic contents (Pl. VIII, figs. 46, 47 *s*).

The remaining tissue of the bundle is parenchymatous, and on account of its disposition in all parts of the bundle, it is impossible to distinguish phloem and xylem parenchyma. It may therefore be termed "connecting tissue" in accordance with Van Tieghem's (1870–71) "tissu conjonctif" or Schenck's "Verbindungsgewebe" (1886, p. 59).

e. Brief Comparative Study of Roots of Other Potamogetonaceae.

In general, *Potamogeton pectinatus* and *Zannichellia palustris* agree with Ruppia in the vascular structure of their roots. The main difference is the presence of only one central trachea, which is considerably enlarged (Schenck, 1886, p. 61, figs. 80, 81). I find no reference in the literature to the cortex or epidermis of these plants, but see no reason why it should differ to any extent from that of Ruppia. Very probably also other slender sub-

merged Potamogetons, such as *P. filiformis*, have a similar root structure.

Another plant, whose roots resemble closely in internal structure those of Ruppia, is *Althenia filiformis*. Epidermis, exodermis and cortex are practically identical with the same tissues in Ruppia, and although Prillieux's (1864) description and figures of the bundle leave much to be desired, there is evidently a strong resemblance to Ruppia.

The structure of the mature root of Cymodocea apparently differs entirely from our plant, most certainly in the composition of the central cylinder, according to Bornet's (1864) description and figure.

D. Functions of the Root

As is well known, the two main functions of the root are—1. to absorb water and watery solutions from the soil, and 2. to act as organs of attachment. That these functions are both of much importance in the roots of land plants is an established fact: that their relative importance assumes the same proportions in submerged plants is not so well established.

Some authorities, such as Sachs (1887) and Vines (1898), have expressed the view that the roots of submerged plants are used mainly as organs of attachment. Schenck (1886, pp. 57, 58) modifies this somewhat, concluding that the absorption is of not much importance, but may possibly supply mineral solutions from the soil.

Strasburger's (1891) view, as expressed in his work "Über den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen," is similar to Schenck's. In the Bonn Textbook (1908, p. 165), however, Noll says, "Wasserpflanzen .... vermögen Wasser und gelöste Stoffe überall an ihrer Oberfläche aufzunehmen. .... Die in den Boden eindringenden Wurzeln vieler submersen Pflanzen tragen aber zur Ernährung und zum Gedeihen dieser Wasserpflanzen wesentlich bei"—thus laying considerable emphasis on the absorptive power of the root.

Pond (1905) has indeed recently proved quite conclusively that this absorption is of more importance than was formerly supposed—to such a degree that, for example, in *Ranunculus aquatilis trichophyllus*, one of the various submerged plants he has experimented upon, specimens rooted in soil exceeded in growth those rooted in clean washed sand 62.96%. Similar results were obtained by him with other submerged plants.

Not only the evident carefulness with which he has conducted his experiments, but also the variety of species and number of specimens used, joined with his very positive results, should put at rest all doubt as to the importance of the absorptive rôle of the roots of submerged plants.

On the other hand, Pond's experiments fail to show conclusively whether or not water and dissolved salts are absorbed by the part of the plant above the soil—a condition which is indicated by the reduction of the xylem area of the root.

Too much emphasis, therefore, must not be laid upon the absorbing capacity of the root, as is shown by the following considerations:—1. the absence of transpiration as we are acquainted with it in land plants; 2. the probable absorption by the parts of the plant above the soil of nutrient solutions from the surrounding water; 3. connected with these two conditions a reduction of the xylem area to a few tracheae of rudimentary nature; and 4. the total lack of branches and the slenderness of the roots.

In brief, the absorption carried on by the roots of submerged plants and the importance of this function in the economy of the plant is much greater than is implied by Schenck, as the experiments of Pond demonstrate; but, on account of the peculiar environmental conditions of submerged plants, it can never equal in importance the absorption of the roots of land plants.

THE ECOLOGY OF THE VEGETATIVE ORGANS

Introductory

In view of the fact that Ruppia is a submerged plant, living under water at all seasons of the year, and unable to live out of it, a study of the methods by which it accommodates itself to this life is of interest, especially when one compares it with a typical land plant.

Of course, in a comparison of these two types, the one point of vital importance to be noted first of all is the radical difference in the nature of their environment: the land plant pushes its stem and leaves into the air, a gaseous medium; while the submerged plant extends its shoots entirely surrounded by water, a liquid medium.

The striking formal, structural, and physiological dissimilarities which obtain between land and submerged plants have their fundamental origin in the physical differences of these two media and the concomitant variations in quality and intensity of light, temperature, &c. These physical factors have already been clearly stated by Warming (1902, pp. 127 ff.), Schimper (1898), and others, so that it is unnecessary to recount them here.

On account of the various methods of ecological classification by different authors, the assignment of Ruppia to a definite ecological group is not as easy as might seem at first sight. Among his four ecological groups Warming (1902, p. 121) defines the hydrophytes as being those plants that are surrounded wholly or for the most part by water, and those that grow in very moist earth. Of the subdivisions of this group the "Enalid society or sea grass vegetation" includes such plants as Zostera, Cymodocea, Phyllospadix, Potamogeton, Althenia, Ruppia, &c. (l. c. p. 156).

More recently, however, a tendency has been manifested to restrict the term hydrophytes to plants of fresh water only (e. g. Atkinson, 1905, p. 484). According to this view Ruppia is excluded and must be classified as a halophyte, an arrangement which seems reasonable, if one accepts the literal meaning of the term "halophyte."

As a matter of fact, a study of the plant shows that the great majority of its adaptive characters fit it for membership in the hydrophytes, and only a few—possibly not more than one or two—features added to its hydrophytic characters would qualify it for

a halophyte. And when one reviews the strikingly diverse characters exhibited by plants living in salty soil—which is the vegetation one naturally thinks of as halophytic—and by those living in salt water, it seems best to avail ourselves of Schimper's (1898, p. 817) terms "land halophyte" and "water halophyte" as a solution of the difficulty.

Considered as a water halophyte, therefore, Ruppia has both hydrophytic and halophytic adaptations. I shall outline first the former, taking up in order those modifications that occur in the shoot and in the root, and secondly describe the halophytic adaptations.

Hydrophytic Adaptations

A. The Shoot

1. Gross Morphological Adaptations.

In its external form and style of branching the stem of Ruppia presents a marked contrast to the stem of a typical land plant. Since water has such a greater density than air, it becomes no longer essential for the plant to have a stout, firm axis capable of holding itself erect and supporting numerous branches. Instead we find the stems of Ruppia long and slim, and except at the very apex, of equal diameter throughout. For the same reason the branches are similar, and as long or longer than the principal axis from which they arise. Hence the peculiar wide-spreading branch system which I have already described—a type impossible in a land plant without a copious development of strengthening tissue.

The leaves of Ruppia, arising from such a weak, slender stem, are of enormous length compared with the leaves of an ordinary land plant having a main axis of similar diameter. This extreme length is again made possible by the greater density of the surrounding medium. A leaf of similar proportions in a land plant would have great difficulty in holding itself out in a plane suitable for receiving the rays of light.

The advantages of this extreme length seem quite apparent. Coupled with the narrowness of the leaf, the effect is just as in aquatics with finely divided leaves, such as Batrachium, Ceratophyllum, &c., i. e., to present a large amount of surface to the water in proportion to the volume of the leaf. This increase in leaf surface is beneficial for several reasons. In all probability much of the nutrient mineral solution requisite for metabolism is absorbed by water plants directly from the surrounding water. Moreover,

both oxygen and carbon dioxide are necessary for the life of the water plant just as in the case of the land plant. Of the gases in solution in water, both oxygen and carbon dioxide are present, indeed, in a greater proportion than in air. The diffusion of these gases, however, takes place much more slowly than in the air, so that the larger the area of leaf surface, the more readily will the requisite amount of gases be absorbed (Warming, 1902, p. 127 and Goebel, 1893, pp. 248 ff.).

It is obvious, therefore, that for the purpose of carrying on its absorption both of gases and nutrient mineral solutions in the best manner possible, the long, slender leaf of Ruppia is an ideal form.

In the salt-marsh creeks and ditches where it makes its home, Ruppia is constantly subjected to the action of fairly strong tidal currents. On this account also it is advantageous to the plant to have slender leaves; for such easily accommodate themselves to these alternately inflowing and outflowing tidal currents. This accommodation becomes the easier from the fact that the leaves are not dorsiventral, but alike on both flat surfaces and, therefore, bisymmetrical; a condition which may be referred to the diffuseness of the light in the water, as well as the constant moving about of the leaves, resulting in a tendency to equality of conditions on both sides of the leaf.

A condition of general ecological significance, which affects all of the vegetative organs, but particularly the shoot system, has to do with the tidal currents mentioned above. At times these currents are even so strong as to detach portions of plants, which I have often observed floating up or down stream, according to the tide. These plant segments become entangled in grass, &c. along the stream edge, or collect in some miniature cove and then begin an independent existence, at perhaps a considerable distance from the parent plant. This is probably a common mode of vegetative reproduction among such water plants.

2. Internal Structural Adaptations.

a. Epidermal modifications.

In many respects the epidermis of stem and leaf clearly reflects environmental influence.

In contrast to the thick outer or free walls of the epidermal cells of land plants, we meet here with a thin wall. Surrounded by water, there is no danger of the drying up of the plant by evaporation from the epidermal cells—a process which, on the other hand, commences immediately on exposure of the plants to the air—and consequently a thick wall would here be superfluous. The fact that even in Ruppia the outer wall of the epidermal cell is slightly

thicker than the others, may possibly be attributed to the necessity for some slight degree of firmness in the covering of the shoot.

Besides the thinness of the walls, the epidermis of the leaf exhibits the following two remarkable peculiarities, which have already been observed in similar aquatics by Warming (1902), Schenck (1886), Goebel (1893) and others, and need not, therefore, be entered into in detail here.

The light is weakened to such an extent by reflection on the surface of the water, absorption in the water, &c., that most of the chloroplasts, for the purpose of the best illumination possible, are located in the epidermal cells, which therefore assume the rôle of photosynthesis, but yet have not at all the shape of the palisade cells of land plants.

As in the majority of other submerged plants, no stomata occur in Ruppia, nor, as already ascertained by Sauvageau (1891, II, p. 209) any of the apical leaf pores found by him in other water plants, so that openings of any kind are lacking in the epidermal covering. The reasons for this, dependent on the characteristic mode of food absorption, the lack of a transpiration current as it occurs in land plants, the extreme permeability of the leaves of aquatic plants to gases, &c., have been fully elaborated by the authorities quoted above (Schenck, 1886 and Goebel, 1893) and need not be dwelt upon here.

It seems to be generally admitted that where stomata do occur in submerged species, they are to be looked upon as hereditary structures, rather than as possessing any ecological significance.

Schenck (1886, p. 6) claims that stomata in submerged leaves are positively harmful, admitting the water into the air reservoirs located in the lacunae. Sauvageau (1891, II), although admitting their uselessness, maintains that they are not harmful to the plant. They have gradually disappeared from the leaves of water plants, not because they are harmful, but because they are useless.

Development of slime. The slime developed by the axillary scales in the shoot has been already treated in detail. It is of ecological significance in that a protection is thus effected for the delicate growing points against their aquatic environment, the protective function of slime being well known (cf. Goebel, 1893, pp. 232–237).

b. Development of Air Spaces.

The formation of large and small intercellular air spaces, most pronounced in stem and leaves, is one of the most striking histological characters of the shoot system. In general, the larger of these air spaces, such as the zone occurring in the stem, and the two

longitudinal rows present in the leaves, receive the special name "lacunae."

The function of these lacunae has not yet been sufficiently investigated. So far as is known, they occur in all water plants. Schenck (1886, p. 49) states that water plants grown on land diminish the size of their air spaces and, conversely, land plants grown under water reveal a tendency toward a loosening up of the cortical parenchyma. This necessarily indicates that the formation of air spaces is in some way connected with and necessitated by an aquatic environment. Haberlandt (1896) has probably hit the truth of the matter when he explains that this is a method of obviating the difficulty of osmotic interchange of gases in submerged plants: "Es wird eine "innere Atmosphäre" geschaffen, mit welcher die geschiedenen Gewebe einen lebhaften Assimilations- und Atmungsgaswechsel unterhalten." The larger these inner air reservoirs are, so much less will the plants have to suffer the difficulties of direct interchange of gases with the surrounding water. It is probable also that the considerable amount of air and gases enclosed in these intercellular spaces is of advantage for submerged as well as for floating plants, by its lessening of the specific gravity of the plant.

c. Absence of Mechanical Tissue.

As has been, in part, pointed out above (see p. 116), a land plant with dimensions of stem, branches and leaves similar to those occurring in Ruppia, must of necessity develop considerable mechanical tissue. But in no part of the vegetative organs of Ruppia is a characteristic thick-walled tissue developed. That such mechanical tissue is entirely absent is to be explained in the greater supporting capacity of water as compared with air, resulting from the greater density of the aqueous medium. In this way this lack of supporting tissue is to be considered as an adaptation to environment.

d. Reduction of the Vascular System.

The vascular system is greatly reduced. If we except the minute cortical bundles of the stem and the small lateral leaf nerves, the entire vascular system of the shoot is represented by a single axial vascular strand. The xylem portion mostly disappears in the mature stages except at the nodal regions, leaving a central cavity in the vascular area. The phloem portion is, however, in all cases intact, consisting of sieve tubes, companion cells and phloem parenchyma.

One may lay this vascular reduction entirely to the different mode of nutrition employed by submerged plants. On the one hand, the food solutions formerly conveyed from the roots by way of the stem are probably now absorbed in large part from the surrounding water,

and on the other hand, the transpiration current, unaided in its work by stomata or even by apical leaf pores, and, moreover, rendered unnecessary by the presence of water on all sides, must inevitably be diminished.

That the sieve tubes and their companion cells should remain intact simultaneously with a complete degeneration of the xylem, seems reasonable when we consider that the function of the phloem is the transportation of *elaborated* food.

In another respect the reduction of the vascular system is of ecological importance; for not only are the vascular elements reduced quantitatively, but also the fact that practically all of the vascular system is concentrated into a single bundle, which is axial, deserves especial note.

That this axial position of the bundle in the stem is considered to have been attained phylogenetically, through a gradual displacement of the more peripheral bundles toward the center of the stem and fusion there into a single concentrically arranged bundle, has already been touched upon in the account of the morphology of the stem (p. 81–82).

Ecologically considered, this axial arrangement enables the plants to bend about easily and accommodate themselves to the movements and currents of water. For the axial bundle of the stem, with its slightly thickened endodermis enclosing the long cells of the vascular tissue, is naturally the region most resistant to bending movements. Now, it may easily be seen that a plant with its vascular area in such a position is capable of bending much more readily than one in which this area is more or less peripheral, as in the typical land plant. Such an arrangement is analogous to the axial strand of roots, and there subserves a similar purpose.

B. The Root

1. Gross Morphological Adaptations.

Another result of the absorption of nutrient solutions by the shoot system directly from the surrounding medium is the great reduction of the root system. This consists entirely of slender, unbranched, adventitious roots arising singly at each node of the creeping stem —a simplicity of form and development which is correlated with the function of the root, and which has been already discussed in detail under the morphology of the root (pp. 103–114).

As has already been pointed out, the development of a coleorrhiza or root sheath may have some bearing on the environment, protecting

the root in its very young stages. It may be here again noted (cf. p. 107) that possibly the soil or the water, containing common salt in solution, would injure the very young root if not thus protected.

2. Internal Structural Adaptations.

a. Air Spaces.

The root cortex, as is the case in the shoot, shows many intercellular spaces, but much smaller. These, however, are often made larger by the collapsing of the cells. The function of these air spaces may probably be explained in the same way as in the shoot (p. 119).

b. Reduction of the Vascular System.

The vascular bundle of the root, of essentially the same structure as that of the stem, admits of the same interpretation, as regards the reduction of its elements, as in the stem. Especially significant is the reduction in this case, however, since the root is properly the absorbing organ of an ordinary plant, and as such should possess at all events a well developed vascular system. The absence of such a one here is the most conclusive proof of the comparative small amount of absorption carried on by the root system.

In this connection the presence of thin-walled tracheal cells without thickenings, still intact in the xylem area of the bundle, is interesting in comparison with the axial canal caused by their dissolution in the stem. Their presence may indicate a need for them in the root, and therefore some degree of absorption by this organ.

Halophytic Adaptations

A. General

It was pointed out by Schimper (1890, p. 1047, and 1891, pp. 25 ff.) that any considerable amount of salt in the cell sap is detrimental to the plant, and that here we have the probable cause of the characteristic halophytic modifications, which aim, therefore, at a lessening of the transpiration current. To this Warming (1902, p. 309, 310) replied that even if transpiration were diminished to a very low degree, slowly but surely an amount of salt would be collected in the plant which would eventually prove fatal. On the other hand, Warming saw better logic in another idea of Schimper (1890), which has become the widely accepted view at the present time—namely, that the protective contrivances against strong transpiration are necessary in halophytes, because absorption of water from a salt solution is slow and difficult.

On account of this difficulty in water absorption, then, one finds exhibited in land halophytes many water-storing devices and typical xerophytic methods of diminishing transpiration.

The water halophytes, on the contrary, especially the submerged aquatics, such as Ruppia, Zostera, Phyllospadix, &c.—members of the Enalid hydrophytic society of Warming (1902, p. 156) as above noted—evince none of these modifications. The hydrophytic adaptations already described for Ruppia show how closely this plant resembles a typical submerged fresh water hydrophyte. Although surrounded by salt water to a much greater extent than land halophytes, yet it shows none of the characteristic xerophytic modifications which are associated with land halophytes in general.

The explanation of this may be based on the fact that transpiration, as such, does not appear in Ruppia. The comparatively small amount of water absorbed by the roots, the absence of any openings in the leaf through which water could pass, such as Sauvageau (1891, II, pp. 127 ff.) has described for Zostera, Phyllospadix, Halodule and Potamogeton; moreover, the fact that the epidermal cells of the leaf, with the exception of the secretion cells, are all photosynthetic and absorb solutions from the outside into the interior, indicate the giving off of a very small amount of water, if any from the leaves. Waste gases, however, can easily pass out through the cell walls in solution. On account of these conditions, structures adapted to the retention of a supply of water and reduction of transpiration, are unnecessary, and we accordingly find an absolute lack of such halophytic adaptations in Ruppia.

B. The Adaptation to a Salt Water Environment

In one particular, however, Ruppia shows a distinct halophytic adaptation. This is exhibited in its power to withstand the plasmolytic action of salt water. Ganong (1903) has found that the root hairs of certain land halophytes possess specific abilities to resist plasmolysis in various solutions of sea water, showing in this way a greater or less halophytic adaptation. He says (1903, pp. 353, 354), "I found a close correspondence between the halophilism of a plant and the power of its root hairs to resist plasmolysis. This power has of course been gradually acquired, but what its physical basis is I do not know; though we shall probably find that substances osmotically equivalent to the salt of the sea water have been formed in the sap of the hairs."

But Ruppia, and all of the allied salt water genera, such as Zostera, Phyllospadix, &c., show an even greater adaptation than

these land halophytes, since they live and flourish entirely in a salt-water medium.

Wishing to ascertain how great a concentration of salt water *Ruppia* would stand without plasmolyzing, I tried first a 105 per cent solution, obtained by evaporating salt water (taken at high tide at Savin Rock, near the entrance to New Haven Harbor), to the desired concentration. As is indicated in the following table, (p. 125), both leaves and root hairs showed occasionally a very slight plasmolysis. In the root hairs, indeed, the protoplasmic movement continued, although in most cases the ends of the hairs, especially, showed a slight plasmolysis. A solution of 110 per cent strength, however, prepared in the same way, produced a marked plasmolysis in both leaves and root hairs.

In order to get a comparison with submerged fresh water plants, I experimented with the leaves and root hairs of Elodea and Callitriche, with the results as shown in the table (p. 125).

Compared with Ganong's results, a few of which also are given in the table, my experiments show that the plasmolysis index in Elodea and Callitriche is about equal to that of Atriplex and Hordeum, so that there is very little halophytic adaptation in this respect in the latter plants. This is to be expected, since Ganong (1903, pp. 359, 360, 364) expressly states that these grow in the higher and drier places of the salt marsh.

Another point illustrated by the experiments with Elodea and Callitriche is the slightly greater resistance in both cases of leaves as compared with root hairs. This is hardly to be looked for, since it would naturally be supposed that the roots would be accustomed to somewhat stronger solutions in the soil and would therefore evince a greater resistance to the plasmolyzing action.

Elodea, as is natural, being a very delicate plant, is more sensitive in both cases than Callitriche.

Being curious to know how much pure salt (sodium chloride) Ruppia would stand, I used solutions of 2.5, 3, and 5 per cent with the following results.

1. Leaves of *R. maritima*, placed in 2.5 % NaCl solution, did not plasmolyze.
2. „ „ „ „ „ „ 3 % „ „ plasmolyzed in 4–5 min.
3. „ „ „ „ „ „ 5 % „ „ „ in about 1 „

Since ocean water in general is known to contain about 3.5 per cent of salts (Atkinson, 1905, p. 622), it would seem from the above that Ruppia could not live in it. And yet, as the table (p. 125) shows, Ruppia does not plasmolyze in the salt water of New

Haven Harbor, and not often even in a 105 per cent strength solution of this.

This would lead one to conclude *a priori* that the water of New Haven Harbor does not contain as much salts as the 3 per cent quantity of NaCl of the above experiment, and certainly not as much as the 3.5 per cent of ordinary ocean water.

On next ascertaining the percentage of salts contained in the water of New Haven Harbor (procured, as in the first experiment, from Savin Rock, near the entrance to the Harbor, at high tide), I found by evaporation that the proportion was about 2.8 per cent, as would be expected from the *a priori* conclusion. This amount, therefore, explains why Ruppia plasmolyzed in a 3 per cent salt solution, but did not plasmolyze in the water of New Haven Harbor.

The sea water used, although purposely obtained at the entrance to the harbor and at high tide, is, therefore, quite brackish. The fact that Long Island Sound is considerably shut off from the ocean and also has several large rivers emptying into it, probably accounts for this. Very probably a similar percentage of salts prevails all along the Connecticut coast.

It is possible that the sea water used in Ganong's experiments had a greater content of salt. If so, his results with Atriplex and Hordeum mean somewhat more than the comparison in the table indicates.

An interesting point which should not be overlooked, since it shows how delicately adjusted these plants are, comes to light in the sometimes slight plasmolysis of Ruppia in the 105 per cent solution. A little calculation shows that this is about identical in strength with the 3 per cent salt solution, at which plasmolysis occurs very slowly. It is perfectly clear, then, that Ruppia is adapted to life in water containing a solution of sodium chloride and other salts; that this solution does not equal in strength that of the ocean in general and hence may be termed brackish; and furthermore, that Ruppia could not live in such ocean water; that this adaptation of the plant is brought about through an ability to resist plasmolysis by maintaining in some way a higher osmotic tension than prevails in submerged fresh water plants, probably by the presence of an equalizing salt solution in the cells themselves.

RELATIVE RESISTANCE TO PLASMOLYSIS.

Percentage of Sea-water	LEAF (epidermal cells)			ROOT (root hairs)			Comparison with Results of Prof. Ganong on Root Hairs of Land Halophytes[1]				
	Elodea canadensis	Calli-triche palustris	Ruppia maritima	Elodea canadensis	Calli-triche palustris	Ruppia maritima	Salicornia herbacea	Suaeda maritima	Plantago maritima	Atriplex patulum	Hordeum jubatum
10	—	—	—	—	—	—					—
20	—	—	—	—	—	—					—
30	—	—	—								—
40	—	—	—	very slight	—						
50	very gradual appearing in about 7 min.	—	—	gradual, but finally marked	gradual					plasmolysis	plas-mo-lysis
60	bet. 40 s. & 2 m.	very gradual 7—9 m.	—	rather gradual but finally marked	rather gradual						
70	35—75 s.	45 s.—2½ m.	—	1 min.	distinct				plasmo-lysis		
80	12—15 s.	45 s.–3 m.	—	1 m.				plas-molysis			
90	10 s. & under	25 s.—1¼ m.	—	30 s.	—	—					
100	immediate	15—45 s.	—	20 s.	—	—	plas-molysis				
105	immediate	im-mediate	occasion-ally very slight	immediate		occasionally very slight					
110	immediate	im-mediate	distinct and fairly rapid	immediate	—	rather slow but finally distinct					

[1] Ganong, in all cases, gives the solution which the plant will "endure without plasmolysis." I assume, therefore, that plasmolysis would occur at the next higher strength of solution.

Adaptation and Heredity

When one reviews the manifold ways in which Ruppia is adapted to its environment, it becomes clear that this plant represents an advanced stage of special evolution, resulting in a particular type of plant, growing entirely below the surface of the water and almost ideally adapted to the novel conditions which present themselves.

That the characters of aquatic plants cannot, however, always be explained on the hypothesis of adaptation, Sauvageau has well illustrated. Another factor should be reckoned with, namely, heredity. For instance, among other examples, Sauvageau (1891, II, p. 121) speaks of *Althenia filiformis* and *A. Barrandonii*, which grow side by side in certain ponds near Montpellier: "Les feuilles de la première ne possèdent jamais d'éléments épaissis; celles de la seconde, au contraire, ont non seulement leur unique nervure entourée d'un endoderme puissant, mais l'épiderme a ses parois plus épaisses, le limbe est parcouru par deux gros cordons fibreux plus ou moins lignifiés, et la gaine en montre plusieurs semblables. Ces faits sont complètement inexplicables si l'on admet l'action prédominante et quasi exclusive du milieu."

It is evident that as Schenck (1886, p. 7) has declared, adaptation and heredity are two opposing factors in the transformation of an organism, and that "l'état anatomique . . . . maintenant dépend assurément non seulement du temps depuis lequel l'adaptation a commencé, mais aussi de leur structure originelle et de leur résistance spécifique à l'adaptation, autrement dit, des caractères qui leur ont été légués par hérédité." (Sauvageau, 1891, II, p. 120.)

One meets in Ruppia very few of these useless structures handed down presumably from former generations. We have seen that the cortical bundles of the stem are evidently rudimentary structures, but one cannot affirm with certainty that they are now useless. Again, the tracheae of the axial bundle in the shoot become so disorganized in the mature condition that it would seem as if here were an ancestral structure which is no longer needed. And, as if to carry out this idea, we find the tracheae absolutely lacking in such highly adapted plants as Ceratophyllum and Naias (Schenck, 1886, p. 30).

Summary

1. It is best to classify Ruppia ecologically as a water halophyte. As such it exhibits both hydrophytic and halophytic adaptations.

2. The hydrophytic adaptations of the shoot are as follows: first, in its external form it shows a weak, wide spreading branch system, with slender stems and long grass-like leaves; second, in its internal structure, it reveals a thin-walled epidermis, photosynthetic and without stomata, in the leaves, a production of slime by the axillary scales for protective purposes, a copious internal development of air spaces, a complete lack of mechanical tissue and a reduction of the vascular system to a single main axial bundle and two small lateral bundles in both stem and leaf.

3. The hydrophytic adaptations of the root are as follows: first, in its external form, a reduction of the root system to small, unbranched, adventitious roots, borne singly at the nodes, and the formation of a protective coleorrhiza; second, in its internal structure, the presence of numerous air spaces and the reduction of the vascular system to a single, axial, concentrically arranged bundle similar to that in the shoot.

4. The characteristic adaptations of land halophytes are wanting here, for the reason that their cause, the need for reduction of transpiration, is lacking.

5. Ruppia shows, however, a remarkably interesting halophytic adaptation in its power to live in salt water, which, when applied to submerged fresh water plants, causes instant plasmolysis.

6. This salt water is not equal in strength to that of the open ocean, containing in New Haven Harbor, about 2.8 per cent of salt, and may therefore be termed "brackish".

7. My experiments show also that this power is confined to a very slight margin, i. e., that slightly concentrated harbor water causes plasmolysis in both root hairs and leaf cells of Ruppia proving that the plant, as now constituted, could not exist in ocean water.

8. The tracheae and cortical bundles are evidently more or less rudimentary and possibly represent useless structures handed down by heredity.

THE REPRODUCTIVE ORGANS

Morphology of the Flower

As a preliminary to the account of the development of the flower and of the reproductive organs, it will perhaps be in the interests of clearness to preface a short description of the mature flower. In this connection I shall also take occasion to discuss briefly some of the more important morphological aspects of the flower.

The flowers of *Ruppia maritima* are small, (3–5 mm. in diameter), consisting of two stamens and generally four pistils, with no perianth, and are borne in a pair at the apex of the peduncle, occurring one above the other, on opposite sides of the rhachis (Pl. IX, fig. 49). The inflorescence is thus spadix-like, a type which is more pronounced in Potamogeton and Zostera.

The mature stamen resembles two thick, rounded, semicircular bands closely appressed to the rhachis (Pl. IX, fig. 49), and meeting each other on opposite sides of it, each band being the half of an anther. In the Bonn Textbook (1908, p. 422), these anther-halves are called "thecae," and because this term is shorter and more specific, it will be used in this paper. A comparison with figure 474 of that textbook (1908, p. 422) demonstrates how a stamen of this sort could easily be evolved by a gradual separation of the thecae. In Ruppia their complete separation at maturity has led them to be interpreted as single stamens with bilocular anthers, for Roze (1894, p. 476) says: "Je n'ai pu y parvenir, car je n'ai jamais trouvé, dans les anthères même jeunes, une adhérence, une soudure quelconque qui le (i. e., cette diminution du nombre des étamines) fît supposer. Et il est bien certain qu'à la maturité des organes, il est impossible de ne pas reconnaître que chaque fleur présente quatre étamines parfaitement libres, ce qui est le point essentiel." Pl. IX, fig. 50, however, gives a correct idea of the morphology of these thecae; for at this young stage the connective shows clearly that the structures on each side of it are merely the two thecae of the same stamen.

At this point, it is interesting to note in Pl. IX, fig. 50 the extension of the connective out beyond the plane of its attachment to the thecae, forming what is described by Irmisch (1851, p. 84) as "ein

kurzer, abgestumpfter, zuweilen etwas ausgehöhlter freier Fortsatz." This develops still further during the growth of the young flower, and sections of it are shown in Pl. IX, fig. 51. Irmisch suggests that this structure corresponds to the pseudoperianth-segment of Potamogeton, which Ascherson (1889) describes as a perianth-like dorsal appendage of the connective. A similar development appears in Posidonia (Ascherson, 1889). That Ascherson agrees with Irmisch's interpretation, is shown by his generic characterization of Ruppia: "Stb. 2, mit sehr kurzen, von den Antherenhälften überragten Anhängseln des Mittelbandes" (1889, p. 207). Eichler (1875, Pt. 1, pp. 89–91) had also supported Irmisch's view.

Čelakovský (1896, pp. 48, 49), on the other hand, believes that these scaly outgrowths from the connective represent reduced floral leaves (Perigonblätter), and deprecates the supposition that they are morphologically portions of the anther connective. Eichler and Ascherson get their strongest argument, of course, from Potamogeton, which shows such a stronger development of this anther-connective structure. Even here, however, Čelakovský (1896, l. c.) sees only floral leaves which have become attached to the connective at its base, mentioning Hegelmaier's (1870) work as one foundation for his opinions.

The development from the connective in Potamogeton resembles strongly a floral leaf, although its connection with the anther-connective is quite pronounced. In the mature flower of Ruppia, after the stamens have fallen away, the same sort of structures may be seen, two in number, at the base of the group of four pistils, and opposite each other. These small structures show a very minute projection, the outgrowth of the connective, as was noted in the young flower (Pl. IX, fig. 50) and below, on opposite sides of it, the scars showing the places where the thecae were formerly attached.

Without going into detail, my own opinion is that the connective outgrowths in Potamogeton represent morphologically perianth segments; that is, I agree with Čelakovský, and if this interpretation is true for Potamogeton, it must be true also for the evidently closely related Ruppia, which, as Čelakovský (1896, p. 49 and 1900, p. 49) emphasizes, is a reduced flower. The reduction is shown not merely in the smaller number of floral whorls, but in this rudimentary condition of the perianth segment.

It will be seen that the appearance of the thecae in the young stage represented by Pl. IX, fig. 50 is much different from that in Pl. IX, fig. 49. As the rhachis elongates, the thecae grow in a

horizontal direction, around the rhachis, closely following its surface, until finally they nearly meet, as in Pl. IX, fig. 49.

The pistils, occurring between the thecae in a group of four, form a diamond-shaped pattern arranged in a transverse position on the rhachis. Each pistil develops, in the mature flower, into a cylindrical structure tipped with a sessile peltate stigma and containing a single ovule.

As regards the number of the pistils, I have never found it to vary; but Ascherson (1889), who divides *Ruppia maritima,* his only species of the genus, into three subspecies, says in his generic characterization, "4 (selten bis 10)". Roze (1894, p. 479), indeed, makes the number of pistils the main specific difference between *R. maritima* and *R. rostellata,* alleging that the former has eight pistils and the latter four. In this vicinity, however, *Ruppia maritima* seems to have always four.

Eichler (1875, p. 89), Irmisch (1851), and other older authorities do not hesitate to allude to the subfloral leaves of Ruppia (the pair at the base of the inflorescence) as the spathe leaves. This homology is not used, however, by more recent authorities. For reasons already adduced, I have applied to them the name of subfloral leaves. As to the spathe, however, it seems quite probable that a rudiment of it is represented in the floral scale leaf. As has been shown (pp. 99–102), its manner of origin, development orientation, etc. all connect it ultimately with the flower, and although its morphological origin is clearly identical with that of a vegetative scale leaf, its relations to the spadix indicate a spathe-like nature. Since the flower of Ruppia represents a much reduced type, we should expect to find such reduced structures here.[1]

Floral Development

With these remarks on the general morphology of the mature flowers, I shall describe briefly the developmental stages of the young flower, from the time when it is first recognizable until about the period when the archesporial cells first appear. From that

[1] I have already indicated (p. 101) that Irmisch overlooked this spathe-like floral scale leaf, and I had been unable to find any reference to it in the literature. At the last moment, however, I find that Griffith (1851 I, pls. 257, 258 and 259; II, pp. 196 and 198) figured and described this structure, considering it a true spathe, and explaining its origin and development essentially as I have done.

point, however, the gross morphological development will be followed during the history of micro- and megasporangia and male and female gametophytes.

Very early the floral rudiment can be distinguished from the vegetative cone by its greater lateral development, giving it a comparative thickness, and because even here the two protuberances, each of which is to develop into a flower, are already apparent (Pl. IX, fig. 52). In Pl. IX, fig. 53 these two floral primordia have become more distinct. Pl. IX, fig. 54 shows a more advanced stage with the floral primordia acquiring the flattened disk form which characterizes them at this period, and the floral scale leaf which, as has been shown, corresponds to the spathe just appearing. In Pl. IX, fig. 55 all of these parts are still more developed, and in Pl. IX, fig. 56 one first sees evidence of a segmentation of the several parts of the flower. At this point each flower is still disk-shaped with the thecae of the young stamens—or their primordia —as four swellings situated diametrically opposite one another—the central part of the disk being elevated and representing the region of the future pistils. The rhachis also first appears well developed here, at least at its base.

Three points of interest will be noted in this early floral development:—

1. The origin of the flowers is lateral, forming a type of inflorescence which is not uncommon, and explained on the hypothesis that the nourishment of the vegetative cone is appropriated by the lateral members (Goebel, 1898, pp. 178, 179).

2. Both flowers in the spadix are of the same age. Their origin in the periblem takes place almost simultaneously, and they remain contemporaneous throughout their entire development. This occurs also in Potamogeton, according to Hegelmaier (1870).

3. The development of the anthers precedes that of the pistils.

Subsequently, the pistils appear as four rounded prominences. These develop by degrees, (but always much behind the staminal development) into the mature, rather cylindrical ovaries surmounted by sessile, peltate stigmas (Pl. X, figs. 58–66).

Microsporangium

The initial cells of the archesporium are first clearly recognizable at such a stage in the floral development as is represented in Pl. XI, fig. 68, where the length of a single young flower in section is

about 0.2 mm. and is about midway between the stages represented in Pl. IX, figs. 55, 56. This stage is signalized externally by the definite appearance of the primordia of pistils and stamens.

Pl. XI, fig. 67 shows the region marked x in fig. 68, being the same section at a higher magnification, and reveals the cells in one of the thecae of the upper stamen. The initial cells, indicated by shading, are distinct from the surrounding tissue by reason of their large size, their large nuclei, their dense cytoplasm, and especially their strong reaction to stain. In these respects, all are essentially alike.

As is apparent, not only the hypodermal layer, but also several of the deeper-lying plerome cells contribute to this group, and since they grade off imperceptibly into the sterile tissue below the theca, it is well nigh impossible to draw a hard and fast line of separation. Thus, it is quite probable that more of the interior cells than I have designated are archesporial.

A point of interest in this connection, and, indeed, an additional proof of the identity of these cells, is their previous history. Up to about the stage represented in Pl. IX, fig. 55, the divisions of the meristematic tissue comprising the flower rudiment follow one another in rapid succession. From that period on, however, there is a slight pause in karyokinesis, with the exception of the divisions in the epidermal region, so that a count of the cells reveals practically the same number in Pl. XI, fig. 67, as at the end of the meristematic condition. But, in the meantime, a considerable enlargement, cell for cell, has occurred. There is, then, previous to the first unmistakable appearance of the archesporium initials as shown in fig. 67, a brief cessation of cell division, more or less complete, during which occurs a marked increase in their size.

In one of the Potamogetonaceae at least, namely, Zannichellia, more or less uncertainty has always invested the origin of the archesporium. Warming (1873, p. 28), long ago, in his study of this plant, was of the opinion that the sporogenous cells did not arise from a single archesporial layer, but was unable to state just how they did originate. Recently, Campbell (1897, p. 41), in his study of the same plant, says,—"The origin of the sporogenous tissue of the anther is not easy to trace, as the archesporial cells are at first hardly distinguishable, either in form or contents from the adjacent cells. As soon as they are recognizable, there is already a group of them whose relation to each other is not entirely clear."

In his work on *Ruppia rostellata* (1902, pp. 4 and 5) Murbeck, indeed, locates a hypodermal archesporial initial layer, which is quite in line with the vast majority of results so far obtained among the Angiosperms. These hypodermal cells divide into primary parietal and into primary sporogenous cells, which develop in the usual way.

As is evident, Murbeck's report does not correspond with what I have seen in *Ruppia maritima*. But the statements of Warming and Campbell are strong evidence that the state of affairs I have described is quite possible. It is well known that Campbell has found a plerome origin for the archesporial cells in *Naias* (1897, p. 13) and in *Lilaea subulata* (1898, p. 8). A careful study of the history of the archesporial initials in *Ruppia maritima* from the meristematic stage, as outlined above, leaves no room for doubt that we are here dealing with a comparatively large group of cells which originates simultaneously both in plerome and periblem. Very probably, as Warming's and Campbell's studies indicate, Zannichellia develops in a similar way. The archesporial initials of *Lemna minor*, as figured by Caldwell (1899, figure 13), to whose paper I shall have occasion to refer more at length later, closely resemble those of *Ruppia maritima*. On the other hand, Wiegand (1899, p. 344) finds the archesporium in Potamogeton traceable to a single hypodermal cell.

Pl. XI, fig. 69 shows a more advanced stage, the length of the young flower (fig. 70), measured as in the preceding case, being about 0.25 mm. One or two divisions have occurred evidently in all the cells. Although the cells representing the parts of the mature microsporangium are as yet entirely undifferentiated as to their contents, yet the manner of cell-division and the orientation of the walls give evidence of a commencement of a differentiation. First, the majority of the hypodermal cells have divided by a periclinal wall, thus separating off the primary parietal layer. Second, at the left of the top of the figure, there is the first indication, by characteristic periclinal and anticlinal divisions, of the future septum dividing the two sacs of the theca.

In Pl. XI, fig. 71, with a length of flower about 0.3 mm, this wall of separation between the two sacs becomes quite distinct. Its cells have a much less dense content than the archesporial cells, and are thus clearly marked off from them, as well as by the orientation of their walls.

A parallel case of a wall formed in an exactly similar way has recently been found by Caldwell (1899, pp. 47, 48) in *Lemna minor*. Coulter and Chamberlain (1903, pp. 39, 40) in commenting

on this condition in Lemna, say, "To divide a large sporogenous mass by sterile plates for better nutrition is too common to call for special remark." As mentioned by Caldwell and Goebel (1898, p. 770), Isoetes presents a similar condition of formation of sterile plates of tissue from a fairly large archesporial mass.[1]

The archesporial cells, therefore, now appear as two definite, rounded, densely staining masses, composed of sporogenous cells, surrounded by a primary parietal layer, which has undergone a periclinal division in two or three places.

The first periclinal divisions in the primary parietal layer have become more general in the next stage, Pl. XI, fig. 73, which is from a flower about 0.33 mm. in length. The septum between the two sacs is also more conspicuous, and divisions continue in the sporogenous tissue.

At a considerably later period, with the length of the flower about 0.5 mm. (Pl. XI, fig. 74), the parietal layers are still two or occasionally three in number. Indications appear here that the tapetum is forming from the marginal sporogenous tissue. Nuclear divisions continue among the sporogenous cells.

Soon after this stage, however, the sporogenous cells attain their final number, and all division ceases, followed by an enlargement to the mature pollen mother-cells, just as Murbeck (1902) has recorded for *Ruppia rostellata.*

Pl. XI, fig. 75 shows how the tapetal cells, now unmistakable in form and structure, bound the sporogenous cells—which may now be termed the pollen mother-cells—and are undoubtedly derived from them. According to Rosenberg (1901, II), Zostera also forms tapetum from the ends of its long sporogenous cells, and Coulter and Chamberlain (1903. p. 37) have shown that this is not unusual nor unnatural. In this respect, together with the number of chromosomes in the dividing sporogenous cells, which I have found to be 16, and also the three or four parietal layers between the epidermis and tapetum, *R. maritima* corresponds exactly with *R. rostellata,* as described by Murbeck (1902, p. 5). It is interesting to note here that Wiegand (1899, pp. 344 and 345), finds in *Potamogeton foliosus* that the tapetum is "differentiated from the wall rather than from the archesporium."

There remain to be mentioned the dissolution of the tapetal cells (Pl. XI, fig. 76), the development of thickenings in the subepidermal layer, and the final dehiscing of the anther by a longitudinal split.

[1] A like situation has been carefully described by Bower (1897, pp. 41 ff.) for Danaea and other Marattiaceae.

Megasporangium

The usual method of development of the megasporangium corresponds in every particular to that of *Ruppia rostellata*, as described by Murbeck (1902, pp. 10, 11), so that it would be useless to duplicate his careful description here. Stated briefly, the process is as follows: At a stage in the growth of the pistil represented in Pl. X, fig. 62, or when it is about 0.25 mm. in length, a hypodermal cell in the young nucellus, in the region marked x, becomes considerably larger than its neighbors, with a larger nucleus, and more densely staining contents. This then divides by a periclinal wall, forming an outer, primary parietal cell, and an inner, megaspore mother-cell. The primary parietal cell now divides twice successively by anticlinal walls, at right angles to each other, forming a plate of four cells, or, through a third anticlinal division, sometimes six cells.[1] During this time the two integuments successively make their appearance. Meanwhile, the megaspore mother-cell enlarges, and with preparations for the first reduction division the history of the female gametophyte begins.

In Zannichellia, Campbell (1897, pp. 45, 46) finds two parietal layers formed at first, but these later divide into several layers. A much greater development of parietal tissue has been observed by Wiegand (1900, pp. 31, 32) in *Potamogeton foliosus* and by Holferty (1901, p. 341) in *Potamogeton natans*. In the latter case it is definitely stated that sometimes eight layers lie between the embryo sac and the epidermis. In other respects the development of the megasporangium in both of these genera is essentially the same as in Ruppia. In Lemna, according to Caldwell (1899, pp. 56, 57), there are not more than two parietal layers formed, and the other details of the megasporangial development are practically the same as in Ruppia.

Coulter and Chamberlain (1903, p. 65) state that the suppression of the parietal tissue among the monocotyledons "is usually associated also with the greater or less development of this tissue," a point which is illustrated here in the Potamogetonaceae by the condition in Potamogeton. "The strongest argument," to quote these writers further, "that suppression of the parietal tissue of the megasporangium is a strong tendency among Angiosperms, is that this condition is universal among the Sympetalae so far as investigated."

[1] Rarely two layers of parietal cells are formed (Fig. 78).

Before I leave the account of the megasporangium, two cases in which the archesporium was undoubtedly two-celled should be recorded. Murbeck (1902, p. 11 and figure 35) has figured a double megaspore mother-cell, which, however, according to his explanation, is caused by the very oblique orientation of the wall between primary parietal and primary sporogenous cells, making this wall almost perpendicular to the epidermis and hence resulting in two large cells, apparently both potential megaspore mother-cells, and bounded exteriorly by the epidermis.

But my first illustration (Pl. XI, fig. 77) shows a clearly differentiated, single, parietal layer and two large megaspore mother-cells with their common wall very distinct and quite perpendicular to the epidermis. The second example has developed somewhat further (Pl. XI, fig. 78), the two megaspore mother-cells having passed through the first division, a cross wall being formed, which divides each into two essentially equal daughter-cells. Here may also be noted the rather uncommon occurrence of two parietal layers.

On the analogy of the microsporangium of Angiosperms, it would seem most natural that multicellular archesporia should occur also in the megasporangium. Through the investigations of Strasburger (1879), Fischer (1880), and among others, especially Péchoutre (1902), we have come to know that such a multicellular archesporium is quite general in the megasporangia of the Rosaceae; and that it also occurs in many other dicotyledonous groups has been sufficiently proven.

On the other hand, the reports of an archesporium of more than one cell in the megasporangium of monocotyledons are meagre, and, as reviewed by Coulter and Chamberlain, may be embraced in two cases, *Ornithogalum pyrenaicum* (Guignard, 1882), and *Lilium candidum* (Bernard, 1900). In these instances the archesporium is presumably always more than one-celled. There are, however, many cases, such as some of the Ranunculaceae, when the archesporial cells vary from one to many (Mottier, 1895, and Coulter, 1898). To such as these last the condition in *Ruppia maritima* is similar.

Female Gametophyte

As it is now regarded, the history of the female gametophyte commences with the preparations for the first division in the megaspore mother-cell. As regards this preparatory stage, I find that *Ruppia maritima* does not deviate essentially from *R. rostellata*,

and I have, therefore, no occasion to alter or add to Murbeck's excellent description.

In brief, the changes are very similar to those which lead up to the first division in the pollen mother-cells. The megaspore mother-cell and its nucleus enlarge, while the latter goes through the synapsis and succeeding stages, the staining reactions being essentially the same and even the fine kinoplasmic fibers appearing in the cytoplasm the same as in the corresponding stages in the pollen mother-cell.

In the spindle formed for the first reduction division, eight chromosomes appear (Pl. XII, fig. 80), as Murbeck also announces in *Ruppia rostellata.* Although the chromosomes are here much thicker than in the sporophytic karyokinesis, they are nevertheless still so small that any definite declaration concerning their shapes and method of splitting is well nigh impossible. Still, as Murbeck has noted, the ring and Y-shaped forms characteristic of the heterotypic division are occasionally apparent.

After the nucleus of the megaspore mother-cell has divided, we find a wall laid down separating the two daughter-cells (cf. Murbeck, 1902, fig. 45). In this connection, reference might be made to the case already noted under the megasporangium (p. 136), where a double megaspore mother-cell was found. producing in each case two such daughter-cells (Pl. XI, fig. 78).

The second division follows closely on the first, with a very slight pause, similarly as in the pollen mother-cells. The two walls resulting from these divisions are, however, laid down at quite different planes with respect to each other, that is, the wall dividing the two inner cells is periclinal, while that separating the two outer is anticlinal. Thus the two outer cells are both in contact with the third cell, and are separated by it from the innermost cell. The plane of the anticlinal wall is, however, obliquely situated with regard to the plane of a horizontal or vertical median section of the megasporangium; in other words, it is oblique to the plane of the paper on which such a section is represented, so that an oblique position of the two upper cells with respect to this plane results.

This arrangement is shown by Murbeck (1902, pp. 13, 14, fig. 51). But often, due partly to the manner of cutting the section and partly to the orientation of the outer anticlinal wall, the position and even the number of cells is not so apparent, since one of the two upper cells then lies more or less completely over the other. Such a case is represented in Pl. XI, fig. 79, which a hasty

glance might have interpreted as three megaspores, the upper two becoming resorbed. But careful focussing discloses another outer cell at a somewhat lower plane. Murbeck (1902) figures a similar case in *Ruppia rostellata.*

This departure from the usual method of division of the megaspore mother-cell, in which, in general, the resulting cells are formed in a straight row, is fully commented upon by Murbeck (1902, p. 13), who states that it has been found also in *Allionia nyctaginea, Helleborus foetidus* and *Ceratophyllum demersum*; and to his work I refer for a fuller account of the whole matter and for literature bearing upon the subject. A concise morphological consideration of such a location of the potential megaspores is also set forth by Coulter and Chamberlain (1903), who although they do not mention the case of *Ruppia rostellata,* note a similar arrangement of the outer two cells as occurring in Butomus (Ward, 1880), Jeffersonia (Andrews, 1895), and Potamogeton (Holferty, 1901).

Moreover, that this position of megaspores is not an invariable rule in *Ruppia maritima,* is shown by such a case as is illustrated by Pl. XII, fig. 81, where the four cells appear in a row, the two outer ones already much disorganized.

Before proceeding further, the condition shown in Pl. XII, fig. 82 should be noted, where the nucleus of the upper of the two daughter-cells has divided, but no wall has been formed, and the whole cell, along with its neighbor below, is undergoing resorption. Such a happening seems natural when one reflects that the division in the lower daughter-cell in general precedes that in the upper cell, producing a tendency by the earlier development of the former, to reduce activity in the upper daughter-cell. It will be seen later that this omission of the wall in the upper daughter-cell is the ordinary occurrence in *Potamogeton foliosus.*

In all cases the lowest of these four cells becomes the functional megaspore, the upper three cells becoming resorbed, as in *Ruppia rostellata* (Murbeck, 1902, pp. 14, 15).

In *Potamogeton natans,* Holferty (1901) describes cases of four megaspores with the same arrangement as in Ruppia, the innermost functioning.

In *Potamogeton foliosus,* described by Wiegand (1900), the condition is quite different and yet exhibits points of similarity. The first reduction division produces two daughter-cells, separated by a wall. The second division then takes place in each of these cells, and the resulting nuclei occupy practically the same positions as they do in Ruppia. No walls are formed after this division,

however. If they were, it is evident that a tetrad similar to that in Ruppia would have resulted. The upper daughter-cell with its two nuclei now becomes disorganized, and the lower cell becomes the embryo-sac, its nuclei producing directly the embryo-sac nuclei.

Zostera marina forms three megaspores, according to Rosenberg (1901, I, p. 9), the lowest functioning. The uppermost, however, in his Figure II looks much like Figure 51 of Murbeck (1902), and like many of my own preparations, gives indications of two cells obliquely arranged.

In Zannichellia the state of affairs is surprisingly different. According to Campbell (1897, pp. 45, 46), a row of three cells is formed, of which the uppermost becomes the functioning megaspore. Since this is so strikingly diverse from what takes place in Ruppia, Zostera and Potamogeton, it would seem as if it needed confirmation.

The functional megaspore now proceeds to the formation of the embryo-sac by a series of stages which are quite in line with those which have been found to be so remarkably constant among the Angiosperms. Pl. XII, fig. 82 shows the megaspore nucleus in process of division, while Fig. 83 discloses the resulting two nuclei, one at each end. Fig. 84 shows the four nuclei coming from these two. Fig. 85 represents a mature embryo-sac with synergidae and egg of characteristic form and structure. The antipodal cells are always three in number, their nuclei being surrounded by a definite layer of cytoplasm and apparently by a thin, membranous wall. Often they appear rounded in form (Pl. XII, fig. 85) and again angular (Fig. 86), in the latter case showing clearly their relations to each other. They resemble strongly those figured by Murbeck (1902, fig. 53) in *Ruppia rostellata* and by Campbell (1897, fig. 109) in *Zannichellia palustris*, and like them are situated in a small pouch at the base of the embryo-sac.

A peculiarity of these antipodals is the conspicuous blue color of their nuclei with the triple stain, showing an unusual tint of the blue, and possibly indicating degeneration. Thus they are strongly contrasted with adjacent nucellar nuclei and may be readily distinguished. They were not observed to divide, however, as in the case of certain recently investigated monocotyledons. Apparently their life is short, for they disappear in stages slightly older than Pl. XII, fig. 85.

Male Gametophyte

Since my studies of the male gametophyte of *Ruppia maritima* agree closely with those of Murbeck (1902), it would be useless here

to go into a lengthy description. For the sake of completeness, however, I will review the more important points, noting a few minor differences from Murbeck's results, and adding a few observations of my own.

We may regard the history of the male gametophyte as beginning with the appearance of the synapsis stage in the pollen mother-cells, which precedes the first reduction division and signalizes the special preparations for that process. Seven different flowers chanced to be fixed during this stage, and the appearance of the pollen mother-cells in all was typical (Pl. XII, fig. 87). The nuclei are very large, but no knoblike processes are appended to them, such as Wiegand (1899) figures for *Potamogeton foliosus.* Although some such appearance was occasionally found, it was not sufficiently general to be called typical of this stage.

In the first reduction division I succeeded in finding several cases of multipolar spindles, as Murbeck (1902, p. 7) has also reported. The two reduction divisions follow one another in rapid succession, forming a tetrad, whose members are oriented to each other after the manner of the four quadrants of a somewhat elongated sphere (see Murbeck, fig. 16). A similar arrangement is figured by Bornet (1864) in Cymodocea, and is not uncommon in the monocotyledons in general. During the two reduction divisions I was able in several cases to count eight chromosomes, which is, therefore, the reduction number, as Murbeck (1902) also found in *Ruppia rostellata.*

In the study of the development of the pollen-grain, as in other structures, I found it of advantage to use a certain definite method of external measurement as an index to the stage of internal development. Thus, in the case of the pollen-grain, I chose the length of the grain, which, from its first formation in the tetrad to the mature condition, increases from about 175 μ to about 550 μ. Although these dimensions are subject to some variation, even in the same pollen-sac, yet they are fairly constant for the same period of growth.

At the time of the formation of the tetrads the nucleus is in an approximately central position. Very soon after, or while the grain is still not much more than 175 μ in length, the nucleus shows a position nearer to one end of the grain (Pl. XII, fig. 88), and a central zone of small starch grains has appeared. Almost immediately thereafter one finds the nucleus at the end of the grain, the starch grains having become considerably larger and uniformly distributed (Pl. XII, fig. 89). A nuclear division now ensues (Fig. 90), and as a result, the small lenticular cell at the end of the grain, the generative cell, is formed (Fig. 92).

As to the number of chromosomes distributed to the daughter-nuclei in this division, it is impossible to state it exactly, after a careful study. Murbeck, however, succeeded in finding a very clear case where eight appeared in the nuclear plate, and judging from the count in the two preceding mitoses, and also from general appearances in the division, it appeared to me as if eight was the most probable number in *Ruppia maritima*. The chromosomes in this division, as in the much later one when two male cells are formed (p. 142), are extremely small—much smaller than in the first and second divisions in the pollen mother-cell—so that even with the highest powers of the microscope they are very difficult to identify.

A few words should be added regarding the generative cell at this period. As Murbeck has noted, its nucleus is smaller than the tube-nucleus, but, judging from the staining reactions of the two, it contains a comparatively larger amount of chromatin. Moreover, a definite aggregation of cytoplasm surrounds the generative nucleus. As Murbeck has announced in *Ruppia rostellata*, so here no membrane separates this cell from the rest of the microspore, and it is evident that one sees here a naked cell, such as occurs in the case of the egg or synergidae of the embryo-sac. On the other hand, Wiegand (1899, pp. 352, 353, figs. 41, 42) finds the generative cell in Potamogeton—which, by the way, is not formed until the "spores reach their full size"—enclosed in a definite membrane. A distinct wall is also found in Typha by Schaffner (1897. I.) and in Naias and Sparganium by Campbell (1897, 1899). Rosenberg (1901. I.) in Zostera mentions only a very indistinct wall at a later stage, when the two male cells are formed, separating them from the surrounding pollen-plasm.

In most cases, though by no means always, a narrow space separates this cell from the rest of the microspore, which a study of a large number of sections shows is undoubtedly due to a contraction. (Pl. XII, fig. 92).

The microspore now enters upon a long period of growth, during which it increases in length from the 175–225 μ of the above described stages to the 500–550 μ of the mature condition. During this period it gradually assumes its curious bow-shaped form, with the characteristic dumbbell-like expansions at the ends, and also a considerable dilatation centrally at the convex side of the bow (Pl. XII, fig. 95).

A pollen-grain so remarkable in shape is not unique among the Potamogetonaceae; for the pollen-grain of Cymodocea is also unusual, being a long filamentous grain measuring, according to Bornet

(1864), ten by about two thousand μ, while the microspores of Zostera (Rosenberg 1901, II) are three by about two thousand μ when mature. Moreover, in Phyllospadix, grouped by Ascherson (1889) with Zostera in the subfamily Zostereae of the Potamogetonaceae, Dudley (1893) has found the pollen grains to measure about four or five by one thousand μ. Dudley (1893, p. 412) states that "They are slightly flattened at the extremity and some are enlarged toward the middle."

During this long period of development to the mature form, several noteworthy internal changes occur. The tube-nucleus (Pl. XII, figs. 92, 93 *tn*) gradually undergoes degeneration, until in the mature grain it often appears fragmentary or angular. The starch grains, so prominent in the early stages, become for the most part smaller and fewer, and one seems warranted in concluding that a part of their substance has been utilized in the formation of the grain.

It is not until the mature condition, or when the pollen is about ready to be discharged, that the generative cell divides. When this is to take place, the latter assumes a position in which its long axis is more or less parallel with the long axis of the microspore. The two resulting male cells remain united as in *Potamogeton foliosus* (Wiegand, 1899), each surrounded by a considerable layer of cytoplasm (Pl. XII, fig. 94).

Moreover, even at this stage, no wall separates the male cells from the cytoplasm of the pollen-grain, but there is a fine cell-plate formed between the two cells. As a slight variation from Murbeck's figure, I find that for the most part in *Ruppia maritima* a moderate constriction occurs between the two male cells, in the region of the cell-plate.

One feature which has not been thoroughly worked out in the pollen-grain of Ruppia and indeed has been much neglected in the study of the male gametophyte in general, is the origin and growth of the microspore wall.

Murbeck (1902) has described the peculiar thickenings of the mature wall, the latter consisting of a single thin layer.

Since I was fortunate enough to have a large number of sections of all stages of the growth of the pollen-grain, the development of the wall from the pollen mother-cell stage to the mature microspore was comparatively easy to trace.

The wall of the pollen mother-cell, after it has separated from its neighbors, is very thin. After formation of the tetrads, this wall thickens and becomes the free or outer wall of the tetrads, while the interior walls of the tetrad are laid down immediately after the two reduction divisions, Pl. XII, fig. 88. These tetrad cells do

not separate: the protoplasts forming the future pollen grains may be said to simply occupy the four quadrant-like compartments in the spherical structure comprising the tetrad. The walls at this stage are of noteworthy appearance by reason of their considerable thickness—being thicker than the wall of the pollen-grain at any future time—and also from their transparency, refracting the light in such a way that they appear gelatinous.

The tetrad walls appear now to expand, leaving the pollen protoplasts naked within them. Such a condition is shown in Pl. XII, fig. 97. Finally the walls entirely dissolve.

Judging from Murbeck's account, these conditions escaped his notice, for he speaks of the *membrane of the tetrads* as showing "noch keine Spur von Oberflächenstruktur" (1902, p. 8).

The process is, however, essentially the same as that described by Strasburger (1882, pp. 87 ff.; 1889, pp. 36 ff.) for the pollen-grain of *Malva crispa* and other plants. Only one marked difference occurs, namely, that in *Malva crispa*, &c. the old pollen mother-cell wall is apparently cast off and does not take part in the wall formation of the tetrads.

From now on a wall develops around the young pollen-grain, but, as in the cases of Naias and Zannichellia, remains a single thin membrane (Pl. XII, fig. 94).

Very early (Pl. XII, fig. 97) the local thickenings begin to be formed on the outer surface of the wall. These in this early stage are difficult to see clearly on account of their transparence. They seemed, however, to be the result of depositions on the wall and not do develop from radial bands in its interior. Ultimately these thickenings appear in the shape of low ridges arranged to form irregular polygons, at whose intersection are short spines, with a slight knob at the end (Pl. XII, fig. 96, *a* and *b*). At the ends of the grain and at its expanded center, these spines become shorter, or are absent altogether (Pl. XII, fig. 94). It is probable that at these localities the pollen tube commences its formation.

Pollination

Ruppia is one of the few of the higher plants to which, in respect of the process of pollination, the term hydrophilous may be applied. In other words, water is the transporting agent for the pollen, instead of the commoner methods by insects or the wind.

According to my own observations, which agree in the main with those of Roze (1894), the process of pollination takes place about as follows. Soon after the extension of the peduncle above the surface of the water, the anther sacs split open by a longitudinal cleft, and the pollen, shed in large yellowish masses, may be seen floating on the surface of the water.

Immediately subsequent to the shedding of the pollen, the rhachis, which up to this time has been erect, commences to incline toward the surface of the water. It becomes more and more horizontal until eventually, after two or three hours, it comes to lie on the surface of the water.

In this position, the stigmas are of course so situated that the floating pollen grains, with which, in the height of the flowering season, the water is fairly well covered, have easy access to them. The final step occurs when the currents of water, always moving in one direction or another in a tidal ditch—or sometimes set in motion by gusts of wind—bring the pollen grains into contact with the stigmas.

Wylie (1904), has described a similar mode of pollination in Elodea. He attributes the floating of the pollen-grains to the air imprisoned between the spines of the pollen-grain and the surface of the water, this being sufficient to keep the grain afloat. Pollination on the surface of the water also takes place in Vallisneria, as is well known. In Zostera, however (Strasburger, 1908, p. 258), pollination is performed below the surface of the water.

Fertilization

No investigator has yet been able to demonstrate the process of fertilization in Ruppia. Murbeck (1902, p. 15) has, indeed, found the pollen tubes in the ovary; but has been unable to distinguish either of the sperm-nuclei in the embryo-sac. For various reasons, he concludes that the act of fertilization takes place very rapidly. If this is true, it may account for the fact that in my own preparations I also have been unable to find any unmistakable evidence of the sperm-nuclei.

As is shown in Pl. X, figs. 62–66, a definite stylar canal exists from the stigma to the cavity of the ovary, but Murbeck (1902, l. c.) claims that the pollen tubes, however, penetrate through the cellular structure of the style to the cavity of the ovary.

Endosperm

The endosperm nucleus is large, and located near the antipodal end of the embryo-sac, or sometimes near the center. Just what nuclei enter into its formation was not ascertained, nor could I determine whether or not in the matter of commencing division it has a slight advantage over the fertilized egg, as Murbeck (1902) declares is the case in *Ruppia rostellata.*

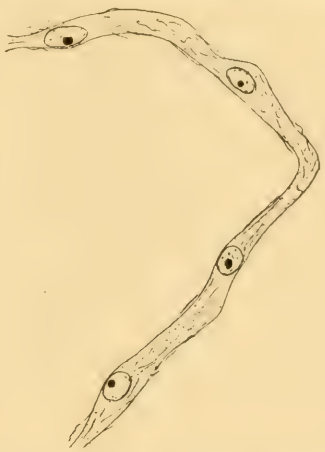


Figure 27.—Portion of endosperm which lines embryo-sac, this particular example being taken from the embryo-sac which contains the embryo shown in Pl. XIII, fig. 106. × 575.

The endosperm in its most fully developed stage (Text-fig. 27), is never more than a thin layer lining the embryo-sac and containing free nuclei. In the mature seed, traces of it may still be seen as a thin protoplasmic lining, with the nuclei now much reduced in size. Thus it is clear that the endosperm is here only temporary. The function of more lasting nourishing tissue is assumed by the enlarged hypocotyl. A similar development of endosperm appears in other Potamogetonaceae (Coulter and Chamberlain, 1903, p. 171).

EMBRYO

The fertilized egg divides transversely, producing al arge lower cell and small upper cell. As in Naias (Campbell, 1897, p. 26), Zannichellia (Campbell, l. c., pp. 27, 28), Zostera (Rosenberg, 1901, I; Hofmeister, 1852), and Potamogeton (Wiegand, 1900), the former divides no further, but subsequently increases vastly in size, developing large vacuoles, and becomes the suspensor, which is thus in this case restricted to a single large, basal cell.

I was unable to discover any stages between the two-celled proembryo and the twelve-celled stage—the latter represented in Pl. XIII, fig. 100. Murbeck, however, figures a three-celled stage in *Ruppia rostellata*, which I reproduce (Pl. XIII, fig. 98), showing two small cells, which may be called the "embryo-cells," arisen from the transverse division of the small upper cell; and also the basal large cell, namely, the suspensor-cell. Wille (1883) figures and also describes a similar stage in his work on the embryo of *Ruppia rostellata*.

Wille has carefully followed the development of the proembryo in these early stages, and his observations and figures accord well with my slightly older embryos. His report of the succeeding divisions is briefly as follows: The lower of the two embryo-cells divides longitudinally, followed by a similar division in the same plane in the upper cell, making four cells in all; next, by longitudinal divisions in both segments, in a plane at right angles to the last, an eight-celled structure is formed. The embryo now consists, therefore, of two four-celled segments lying one over the other, and borne on a single large suspensor-cell (Pl. XIII, fig. 99.)

It should be borne in mind that this suspensor cell is the basal segment resulting from the first division of the fertilized egg, and never again divides. In this connection it may be well to follow out the subsequent history of this peculiar suspensor before going into an account of the embryo proper.

After the first unequal division in the fertilized egg-cell, the suspensor-cell becomes rapidly larger, and at the time when the two four-celled segments appear, as described above, it is much larger than these combined (Pl. XIII, fig. 99). At the period shown in Fig. 100, when the embryo contains twelve cells, the suspensor-

cell nucleus, with the majority of the cytoplasm, occupies a position at the base of the cell, the upper part containing one or more large vacuoles. This appearance, although not invariable (cf. fig. 101), seems a quite general one in the disposition of the cell-contents at all stages except the very earliest. The same has been noted in Zostera (Rosenberg, 1901, I, pp. 11, 12) and Potamogeton (Wiegand, 1900, p. 37).

Although the suspensor-cell is now (Pl. XIII, fig. 100) enormous in size, this is in fact only a stage in its enlargement. Fig. 101 testifies to what proportions it eventually attains. At the same time its nucleus attains a large size. In somewhat later stages the suspensor-cell commences a gradual disintegration, until, at a period of embryo development, such as in fig. 106, the outlines of the cell can be no longer distinguished, although its nucleus is still apparent in a condition of disorganization.

During its development, the suspensor-cell is in contact with the micropylar end of the embryo-sac for some time, but may eventually become free, as Wiegand (1900, pp. 37, 38) has also noted in Potamogeton.

In connection with this remarkable growth, the statements of Rosenberg (1901, I, p. 12), who describes a similar suspensor in Zostera, may be quoted. In writing of the nucleus of this cell he says: "Der Kern des Embryoträgers .... macht eher den Eindruck, als ob in demselben eine rege Stoffbildung vor sich ginge; etwa eine Aufnahme von Stoffen, die in dem Kern weiter umgebildet werden, um später in das Embryo zu gelangen." It might be added that not only the nucleus, but also the whole cell, judging from its appearance and time and manner of development, has obviously the function of reception and preparation of nourishment for the embryo. It is significant also to note that at the time of the degeneration of this large suspensor-cell, the endosperm nuclei are relatively abundant.

Although a similar large basal cell occurs in Naias (Campbell, 1897, p. 26), Zannichellia (Campbell, 1897, pp. 27, 48), Zostera (Rosenberg, 1901, I, pp. 11, 12) and Potamogeton (Wiegand, 1900, p. 37), only in Zostera does it represent the entire suspensor as in Ruppia. In the remaining genera other small secondary suspensor-cells are formed above the large basal cell.

It will be seen that the three-celled stage of the proembryo (Pl. XIII, fig. 98) is essentially similar to that of Sagittaria (Schaffner, 1897, II, p. 262 and Pl. XXIV figures 46, 47) and Alisma (Schaffner, 1896, pp. 129, 130), which has been regarded as typical of the

monocotyledonous embryo (Coulter and Chamberlain, 1903, pp. 188, 190 ff.).

Instead of the increase of this row of cells from three to four, or, in other words, to a row of three embryo-cells, as is the case in the above-mentioned genera, Wille, as already stated, finds that two plates of four cells each are formed from the two embryo-cells. These two resulting four-celled segments are, nevertheless, still the representatives of the two small embryo-cells, which are formed first, in Ruppia as well as in Sagittaria and Alisma.

That this condition is the usual one in Ruppia is shown not only by Wille's (1883) observations, which may be correlated so well with my own, but also by the figures and description of Hofmeister (1852, p. 143 and figures 41–46, and 1861, figures 1–7, pl. II)[1].

My twelve-celled embryo (Pl. XIII, fig. 100), composed of three four-celled plates, has obviously arisen by a transverse wall through one of these four-celled segments—which one, it is not possible to state. In the typical embryo of Sagittaria, indeed, it is the lower of the two segments that undergoes a transverse division (Schaffner, 1897. II, p. 262 and Pl. XXIV, figures 46, 48, 49), and this may be the case here.

What has occurred then is simply the formation of three segments, one above the other, comparable to the three upper cells in Sagittaria (Schaffner, 1897, II, Pl. XXIV, figures 48, 49), with the difference that in Ruppia longitudinal divisions precede the transverse ones.

A comparison of this stage with those embryos of related genera which have been worked out, brings to light the following points. The embryos of Zannichellia (Campbell, 1897, p. 48 and cf. fig. 63 Pl. III; Hofmeister, 1861, Pl. I, fig. 18) and Potamogeton (Wiegand, 1900, pp. 37, 38, and Pl. VII, figures 25, &c.) are essentially like that of the typical Sagittaria, consisting of a row of three cells above the suspensor-cell, the terminal one being the first to undergo longitudinal divisions.

As to the embryo of Zostera, it was investigated at a very early period by Hofmeister (1852), and quite recently by Rosenberg (1901, I). Their results are not complete in the early stages, but enough has been shown to indicate that Zostera is more like Ruppia in the early development of its embryo than any of the Potamogetonaceae so far investigated. Hofmeister (1852, p. 139) states that

[1] Practically the same figures are presented in each of these articles: in the former, the species is given as *rostellata*, in the latter, as *maritima*.

a four-celled embryo is formed from the first embryo-cell by two longitudinal divisions occurring at right angles to each other, and these quadrant-like cells are next each divided by a transverse wall. So that, although the divisions here occur in different sequence, the two four-celled segments nevertheless result.

Although these first stages were not followed out by Rosenberg, he presents a figure (1901, I, Pl. I, fig. 20, and P. 12) of an eight-celled embryo similar to that of Wille's (Pl. XIII, fig. 99). It is perhaps possible that later investigation will show that the first wall in Zostera is transverse instead of longitudinal, as Hofmeister has described it.

The task of tracing out the lines of demarcation of the primary segments during the later stages, after the manner of recent embryological investigations, is very difficult, probably from two principal causes. First, the remarkable number of early longitudinal divisions which have already been indicated to a certain extent obscure the segment limits. Second, the form of the mature embryo differs so widely from that of a typical monocotyledon that even in the early developmental stages this influence makes itself felt, and renders comparison with type forms rather unsatisfactory. Wille, indeed (1883, pp. 2, 3), describes his eight-celled stage as forming a sixteen celled structure by transverse divisions in all of the eight cells. But of the subsequent divisions he says (l. c., p. 3), "Herefter gaa Delingerne uregelmæssigt, saa man ikke længere med Bestemthed kan følge de enkelte Cellers Delinger."

Of stages older than the eight-celled embryo of Wille and Hofmeister, I was fortunate in having a fairly large number, and in the following description I shall attempt to show to what extent the segment boundaries may be traced during the embryo development, and how they may be correlated to such a type as Sagittaria.

I have already suggested that such an embryo as is represented in Pl. XIII, fig. 100, composed of twelve cells, or three four-celled segments, arises from Wille's younger form by a transverse wall through one of the segments, and that this is parallel to the case in Sagittaria, where a three-celled row arises by a transverse division in the lower embryo-cell.

Fig. 101 is a slightly older embryo, in which the divisions are somewhat irregular, but still admit of an interpretation which reveals the outlines of the cells and segments in the preceding stage. It is evident that a transverse division has occurred in the terminal segment.

In fig. 102 appears evidently the beginning of the formation of the dermatogen, at least in the terminal segment at the left. Fig. 103 shows the segment lines more irregular, the dermatogen has became more pronounced, and in fig. 104 shows a distinct differentiation. A point of interest at this stage is the considerable increase in size of all the cells, which are, however, only slightly greater in number than in fig. 103. The embryo here measures about 0.075 mm. in diameter, as against the 0.05 mm. of the preceding one.

Up to this point the embryo has exhibited a globular form, but in fig. 105, where it measures about 0.085 mm. it has commenced to elongate. It is at this period that the divisions are initiated in the terminal segment, appearing here at the left, which signalize the approach of cotyledonary development.

It has been shown by Schaffner (1897, II, pp. 263–265) in Sagittaria that of the proembryo of three cells, the uppermost develops the cotyledon, the middle divides transversely, and of the two resulting segments the upper develops the stem apex and the lower the hypocotyl, root, and secondary suspensor. The lowest cell of the three-celled proembryo remains undivided, forming the basal suspensor-cell.

Obviously the primary segments in Ruppia do not all have destinies similar to those of Sagittaria. For, to begin with, no secondary suspensor is here found, and only a minute rudimentary root, as will be shown later. Again, it seems quite probable, although for the reasons stated above no conclusions can be certainly drawn, that the terminal segment produces the stem-apex as well as the cotyledon. Campbell (1897, p. 49) finds such a condition in Zannichellia, and the appearances shown in fig. 106 point to such a situation here. Solms-Laubach (1878), as noted by Campbell, has also reported a terminal origin of the stem-apex in some of the Commelinaceae and Dioscoreaceae. This leaves the second segment (which, as has already been indicated, probably divides transversely to form the second and third segments, as in Sagittaria) for the development of the hypocotyl, extraordinarily large in Ruppia, and the small rudimentary root adjacent to the suspensor-cell.

Pl. XIII, fig. 105, however, represents the oldest embryo in which the primary segments can be determined with accuracy. In the next figure (fig. 106), it is quite impossible to make out definitely the line separating the terminal segment from the rest of the embryo, to say nothing of any other segment-lines. Nevertheless, in this embryo, cell divisions are active in the terminal region

and one can easily see a small prominence (fig. 106, *cot*), accompanied interiorly by a number of cell-divisions, which is obviously the beginning of the cotyledon. Moreover, at its right is another markedly meristematic region, the future stem apex or epicotyl (fig. 106, *st*).

Wille's description of the subsequent development up to the mature embryo agrees essentially with my slides, so that I confirm his observations in the main, adding a few details. For the sake of clearness, each member will be described separately.

The Cotyledon. Originating as described above, the cotyledon elongates and the epicotyl develops at its base. In the course of its growth, the cotyledon develops basal sheaths similar to those characteristic of the leaves of a mature plant, which then surround the epicotyl. Concerning this condition Wille (1883, pp. 3, 4) says, "Hos den modne Frugt er Plumulaen ganske omgiven af Cotyledonet (Tavl. I, fig. 25), kun en trang Spalte fører ind til Hulen," but figures an embryo with a large open hollow at the base of the cotyledon, where the epicotyl may be seen. As a matter of fact, in *Ruppia maritima* at least, the cotyledonary sheaths overlap one another for almost the whole of their length, essentially as do the sheaths of the foliage leaves (Pl. XV, fig. 118). Only at the upper end of these sheaths is there a small cleft remaining (Fig. 118, *x*) which may be the "trang Spalte" mentioned by Wille. Thus the sheaths enclose the epicotyl so that it is quite shut off from view. In Pl. XIV, fig. 112, and Pl. XV, fig. 116 these sheaths appear in section in not quite mature embryos, and figures 117 and 118 show them in a cotyledon dissected from a mature embryo. It is interesting to note that the axillary scales may be seen within the sheaths, at their base, as in the mature plant.

Wille (1883, Pl. I, fig. 25) figures the cotyledon as elevated a considerable distance above the hypocotyl, although still extending more or less horizontally, and one might conclude that possibly herein is a specific difference between *Ruppia rostellata* and *R. maritima*, were it not for the fact that Irmisch (1858, fig. 37, pl. I) figures the cotyledon closely appressed to the hypocotyl as I find it in *R. maritima* (Pl. XV, fig. 119). In Text-fig. 28, p. 152, this horizontal position has been slightly disturbed through manipulation.

The Epicotyl. Pl. XIV, fig. 112 shows the epicotyl in a nearly mature embryo. It consists always of a second leaf and the growing point, the latter not appearing as prominently here as in other sections. Wille (1883, p. 3, figs. 25 and 26) is in doubt whether this smaller pro-

tuberance is really the growing point or the third leaf, but a comparison with the growing point of the mature stem (Pl. I, fig. 1; Text-fig. 2, p. 75) conclusively proves its nature.

The Hypocotyl. The great bulk of the embryo is taken up by the hypocotyl (Pl. XV, fig. 119, Text-fig. 28), which is nothing but a mass of storage tissue, its cells being gorged with large starch grains. Even in such a young stage as in Pl. XIII, fig. 105, the cells in this region are distinctly larger than in the remainder of the embryo. They continue their enlargement and acquire an ever richer content of starch as development proceeds (cf. Pl. XIII, figs. 105, 106; Pl. XIV, figs. 110–112, 114; Pl. XV, fig. 115).

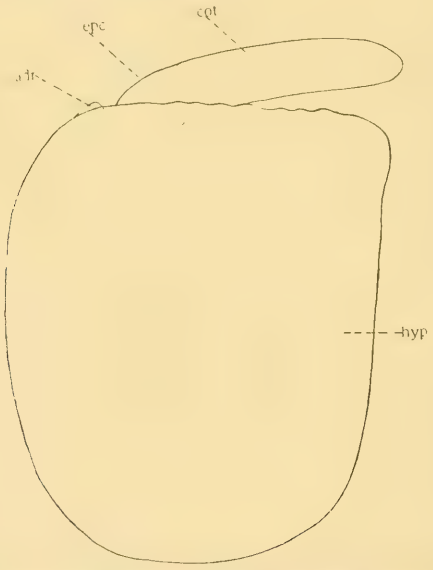


Figure 28.—Mature embryo dissected from ripe seed, the cotyledon slightly elevated during manipulation. *cot*, cotyledon; *epc*, region of epicotyl; *adr*, adventitious root; *hyp*, hypocotyl. × 35.

The Primary Root. At a fairly early period (Pl. XIII, fig. 106; Pl. XIV, fig. 110) a certain group of cells becomes differentiated at the base of the embryo, by acquiring denser contents and lacking the starch grains of the storage cells above them. Each of these cells later develops (at least those on the periphery of the embryo) into unicellular papilla-like projections, essentially as figured and described by Wille (1883, p. 4 and Pl. I, fig. 19) and Murbeck (1902, pp. 17, 18 and figs. 60 b, 61 b). Like Murbeck, I find also often more than a single layer, but whether arising from periclinal divisions in the

dermatogen, as he asserts, I was not able to determine. The whole group is supposed to represent the vestiges of the primary root (Murbeck, 1902, p. 18; Wille, 1883, p. 4), which develops only to this rudimentary degree, and never functions.

The First Adventitious Root. At about the period when the cotyledon and epicotyl have become quite distinct in outline, the formation of an adventitious root occurs near the base of the epicotyl. This grows rapidly, forming a noticeable protuberance (Pl. XIV, figs. 112, 113), and in the mature embryo (Text-fig. 28) may be seen pointing almost directly upward, or nearly at right angles to the position of the cotyledon.

The distribution of the meristematic regions at the tip of this adventitious root is not as clearly marked as in the roots of the mature plant. It will be recalled that the roots of the mature plant, as in Zannichellia, contain at their tip four distinct meristematic regions, representing the initial areas of calyptrogen, dermatogen, periblem and plerome.

In the young adventitious root of the embryo an interesting point is the division of the epidermis of the hypocotyl, immediately over the young developing root, by periclinal walls, apparently to form root cap. These divisions continue, and anticlinal as well as periclinal occur. This is a very different condition from that in the roots of the mature plant.

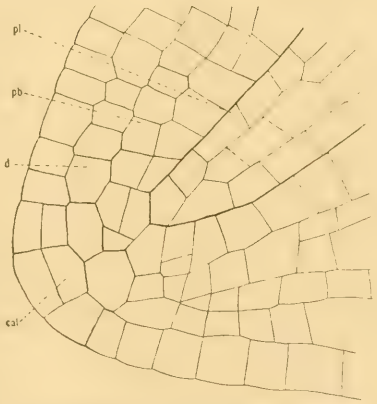


Figure 29.—Longitudinal section through apex of adventitious root of nearly mature embryo; showing *pl*, plerome, *d*, dermatogen, and periclinal divisions initiating development of calyptrogen, *cal*. × 530.

Whether the dermatogen and periblem are each also here represented by a single layer at the apex of the growing-point would be impossible to assert definitely, on account of the irregularity of the cells, but such seems to be often the case (Text-fig. 29). However, some embryos show only one layer for both dermatogen and plerome. as Campbell finds most usual in the primary root of Zannichellia (Campbell, 1897, p. 51). The plerome is pretty clearly marked (Text-fig. 29), but also does not have as definite a point of origin as in the roots of the mature plant.

The mature embryos of *Ruppia maritima* measure 1.5–2 mm. in length, by a little more than 1 mm. in width. Although I find no measurements recorded of the embryos of *R. rostellata*, Irmisch's figure (1858, fig. 37, Taf. I) is somewhat longer in proportion to its width.

Murbeck (1902, p. 18 and Pl. III, figs. 62, 64, and 65) has called attention to the resemblance of this curious embryo of Ruppia to those of the related genera, Zannichellia, Halophila and Zostera. The embryo of Phyllospadix is similar, but characterized by a peculiar lobing of the hypocotyl around the base of the cotyledon (Dudley 1893, p. 413 and Pl. II, fig. H).

To the well known controversy regarding the real nature of the adventitious root and of the primary root, I will briefly allude and record my own views here.

In writing of the Potamogetonaceae, Ascherson (1889, p. 200) says, "Meist entwickelt sich eine kräftige Hauptwurzel an dem unteren Ende des Embryos; nur bei Ruppia befindet sich dieselbe seitlich neben der Plumula."

Thus Ascherson, whose view has been adopted by Goebel (1898, pp. 464–466), rejects the conclusions of Wille, who found the peculiar cell-group developed in *R. rostellata*, which I have also reported for *R. maritima*, at the base of the hypocotyl and immediately over the large suspensor-cell. This basal region is, as Wille says, the place for the primary root of the embryo. Wille, therefore, considers this the rudiment of the primary root, and the structure near the base of the plumule, which Ascherson calls the primary root, he terms an adventitious root.

Murbeck agrees with Wille and in further investigations finds that the primary root rudiment "sich eben am Festpunkte des Embryos, mit anderen Worten, eben am Platze der Radicula befindet. Dass dieselbe wirklich die Anlage der Radicula repräsentiert, kann wohl schwerlich bezweifelt werden" (1902, p. 17).

That the adventitious root is of exogenous origin is explained by Wille (1883, p. 5) and defended by Murbeck (l. c. p. 18) by the fact that practically all of the cells of the young embryo are meristematic, so that an adventitious root developing at this period may easily have an exogenous origin.

My own slides testify to the correctness of the interpretations and figures of Wille and Murbeck. Nowhere is there the least evidence that the hypocotyl is the "seitliche Auftreibung" described by Ascherson, and there seems no doubt but that the root near the base of the epicotyl is properly the first adventitious root, which

has assumed the function of the primary root of the embryo. Such an adventitious root, we have seen, may occur in a similar way at any node in the mature plant, just below the point of leaf-insertion.

Just what the group of cells at the base of the hypocotyl does represent is difficult to say definitely. Murbeck thinks that they may represent calyptrogen and calyptra (1902, p. 18). This is, of course, possible, but it would be difficult to prove. We may be sure of this much, however, that from their position, appearance, and development, they bear some relation to the now functionless primary root.

Another interpretation of this whole thickened hypocotyl with its curious basal cells seems plausible, namely, that practically the whole swollen area itself represents the primary root or radicle which has been by degrees metamorphosed into a storage-organ. That this is actually what has happened would be difficult to prove, for it is dangerous to lay much stress on the form and position of the storage organs. The strongest grounds for such an opinion are drawn from a comparative morphological study. The embryo of Zannichellia, e. g., is very similar to that of Ruppia. Although Wille considers (1883, p. 7) that the small caplike body at the base of the hypocotyl comprises the entire root, Campbell's figures and description (1897, pp. 50, 51 and Pl. V, figures 120, 122, 123) go to show that practically the whole hypocotyl is a root structure and the small body at its base is the root cap.

In Zannichellia the primary root functions for a time during germination (Wille, 1883, p. 8). The absence of a distinct plerome and periblem in what has been called the hypocotyl of Ruppia may be accounted for by the degeneration of this tissue, its assumption of the function of storage, and the transfer of its functioning power as a root to the adventitious root.

FRUIT AND SEED

Pl. IV, fig. 13 shows a cluster of mature fruits, and, as may be seen, the form varies somewhat, but is always bluntly pointed at the apex, with a one-sided base, the whole being slightly oblique with respect to the axis of the stipe. At the maturity of the fruit, the stigma generally drops off, leaving the blunt apex shown in the figure.

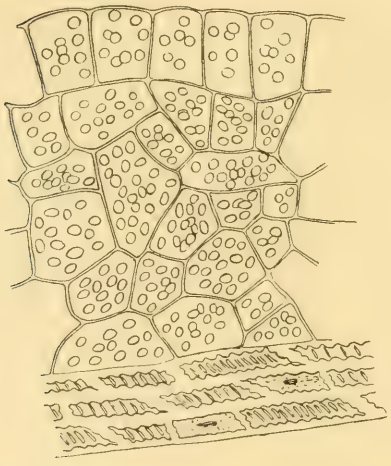


Figure 30.—Section through ovary wall of ripe fruit, showing the three innermost hardened layers, which form the covering of the seed, and the outer soft parts. × 210.

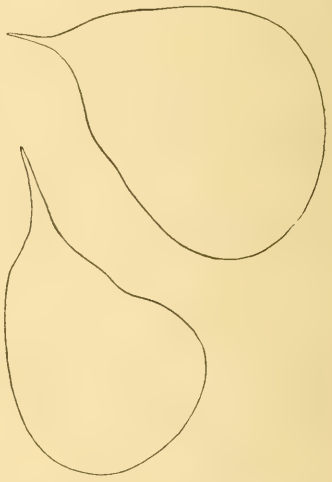


Figure 31.—Two ripe achenes, after disintegration of the outer soft parts of the fruit covering; showing the pronounced beaks. × 35.

During the development of the seed, changes occur in the wall of the ovary, the most important of which is the thickening of the cell-walls of portions contiguous to the seed, with the result that this inner layer of the ovary-wall becomes quite hard. This hardened portion is limited to about three layers of cells. Outside of this hard layer are about five or six layers of thin-walled cells, copiously supplied with starch, and these, in turn, are bounded by the epidermis, also rich in starch (Text-fig. 30).

The ripened fruit has a greater specific gravity than water, which one can easily demonstrate by breaking off the fruit from the stipe. It then sinks immediately to the bottom, and, in most cases, probably passes the winter embedded in the mud. Under such conditions, the outer soft parts of the fruit-covering soon decay, leaving the inner thickened portion of the ovary-wall which surrounds the seed. Since this area extends up into the stylar canal, the result is an appearance as in Text-fig. 31. At the end is a long beak, derived from the stylar region. Such a structure is accordingly an achene, its outer layer being hard, dry and indehiscent, and derived from the ovary.

A prominent beak is supposed to be a specific character of *Ruppia rostellata*. But a comparison with the figures of Irmisch (1858) of *R. rostellata* demonstrates that the beak represented there is not any longer than that of my specimens, although of a slightly different shape.

A similar development of fruit and seed is indicated by Campbell (1897) in Zannichellia, where a seed is formed surrounded by a pericarp from the ovary-wall. Such achenes are also well known to occur in the grasses.

SEEDLING

Germination. A considerable number of seeds were germinated in the laboratory. Seeds gathered in October, at the end of the flowering season, first began to germinate in December, and from that time on seedlings appeared intermittently. It is evident, therefore, that the seed requires a short period of rest before the new growth begins.

Seedlings were grown either in mud from their native habitat, or in clean-washed sand, the latter being preferable, on account of the numerous algae, bacteria, &c. which soon develop in the former. The salt water used was taken from New Haven Harbor.

Irmisch (1858) noticed in the achene of *Ruppia rostellata* a small, slightly swollen, elongated area which he claimed was the place of exit for the cotyledon and root on germination. Such a spot occurs also in *Ruppia maritima*, but I have been unable to ascertain definitely if this is the region which is ruptured at germination. In most cases a more or less triangular area of the hard, dark-brown covering is pushed off and the cotyledon and adventitious root make their appearance (Pl. XV, fig. 120). In figure 121 the whole pericarp has been purposely removed to show the enormous hypocotyl.

Figure 120 shows a seedling about three days old. Here the three vegetative organs are disclosed: the first foliage leaf is developed from the cotyledon, which becomes green; the stem is formed by the elongation of the hypocotyl; and the root grows rapidly downward, becoming abundantly furnished with root-hairs.

In the case of the root, it is interesting to note that it exhibits a general tendency to first grow upwards for a short time, only later turning downward. The proportional growth of roots and leaves seems to vary considerably (Pl. XV, figs. 120, 121).

Formation of Rootstock. Text-figs. 32 and 33 are drawings—natural size—of seedlings grown in the laboratory in washed sand and harbor water. The seeds were collected in January, being extracted from mud taken from the bottom of a ditch where *Ruppia maritima* grows and fruits abundantly, many of the parent plants being even at that time in a green, flourishing condition. On being placed in a warm room, germination occurred in a few days.

During their growth the young plants showed very clearly the manner in which the horizontal rootstock is developed. At first the seedling is erect, but soon, as it increases in length, reclines

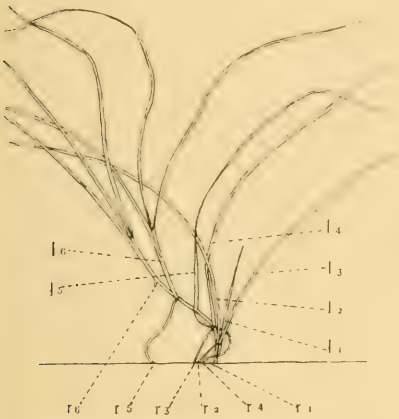


Figure 32.—Young seedling, showing development of horizontal rootstock. *l1*, *l2*, *l3*, &c., successively older leaves; *r1*, *r2*, *r3*, &c., successively older adventitious roots. ½ natural size

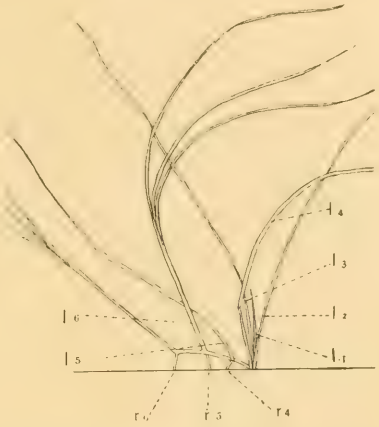


Figure 33.—Young seedling, older than preceding one, showing more advanced development of horizontal rootstock. Abbreviations as in previous figure. ½ natural size.

somewhat, and at the same time an adventitious root (Text-fig. 32, r_1) appears at the first node and grows downward, fixing itself in the soil or sand. This is repeated at successive nodes, the shoot reclining more and more, and Text-fig. 32 shows an advanced stage where five adventitious roots have been developed, and a sixth (r_6) is just appearing. Three days after the drawing was made, this sixth root had reached the surface of the sand. In this figure the roots have almost the appearance of drawing down the stem to a horizontal position. Whether or not this is actually the case, a horizontal location is ultimately attained, as in Text-fig. 33. Here, indeed, the first roots have apparently drawn the oldest part of the seedling well down into the sand.

From this time on the seedling assumes the habit of the mature plant. From the nodes upright shoots may arise, which may also develop later in the same way into root stocks, thus forming a branched rootstock; or it is conceivable that these upright shoots may continue in an erect position, ultimately reaching the surface of the water and flowering.

The anatomy of the seedling corresponds in the main to that of the mature plant. The central vascular area in the stem is thus essentially the same as in the older plant, so that no ancestral characters were detected in the vascular system in this young stage.

SUMMARY OF PARTS ON REPRODUCTIVE ORGANS, EMBRYO, &c.

Flower. The inflorescence is spadix-like, and even a small spathe is present, the latter structure having almost entirely escaped the notice of investigators.

The small scaly outgrowths from the anther-connective probably represent reduced floral leaves, judging from the analogy of Potamogeton, and from the fact that the flower of Ruppia is evidently a reduced one.

The two flowers of the spadix arise laterally from the vegetative cone; they develop practically together in point of time, and the anthers precede the pistils in development.

Microsporangium. Appearances indicate that the archesporial initials in the microsporangium are a comparatively large group of cells which originate simultaneously both in plerome and periblem.

A plate of sporogenous cells becomes differentiated to form the future septum dividing the two sacs of the theca.

The tapetum is evidently derived from the sporogenous cells.

The sporophytic number of chromosomes was definitely ascertained to be sixteen.

Megasporangium. The megasporangium arises from a hypodermal cell in the usual way. Generally one layer of parietal cells is formed.

An interesting case was found of two megaspore mother-cells in one megasporangium, a condition little known among monocotyledons.

Female Gametophyte. Eight chromosomes appear in the first reduction division, and probably in the succeeding ones.

A double megaspore mother-cell was found, which had in each case divided into two daughter-cells.

The four potential megaspores are oriented in such a way that the two outer cells are in contact with the third cell, but separated by it from the innermost cell.

The embryo-sac develops in the usual way and always from the innermost potential megaspore, the outer ones becoming resorbed. The antipodal cells are surrounded by cytoplasm and a thin membrane, and are always three in number. No further divisions among them were observed.

Male Gametophyte. The tetrads are oriented to each other like the four quadrants of a sphere.

Eight chromosomes appear in the reduction-division.

The generative cell is formed very early in the development, at the end of the young pollen-grain. No membrane now or later separates it from the rest of the grain.

When the grain has nearly reached maturity, the generative cell divides, the two resulting male cells remaining united.

The mature pollen-grain is of peculiar shape, but similar forms occur in other Potamogetonaceae.

The wall of the pollen-grain is formed inside of the walls of the tetrads, these latter walls becoming apparently dissolved.

The wall is never of more than a single layer. The thickenings on its exterior appear to be the result of depositions. At certain regions these depositions are omitted, and these spots are probably the places where the pollen-tube may commence its formation.

Pollination. Pollination is accomplished by means of water, an unusual method.

Endosperm. The endosperm is scanty, never more than a thin layer lining the embryo-sac, and containing free nuclei.

Embryo. The suspensor is limited to a single large cell, which later develops to an enormous size.

The embryo evidently develops from two or three primary segments as in the typical monocotyledonous embryo.

An unusual state of affairs exists, however, in the large number of early longitudinal divisions.

Apparently both cotyledon and stem-apex arise from the terminal segment as in Zannichellia, but this cannot be definitely proved, on account of the obscurity of the segment boundaries.

The two lower segments form hypocotyl, adventitious root, and primary root.

I agree with Murbeck in locating the vestiges of the primary root at the base of the enlarged hypocotyl.

Another possible interpretation is that practically the whole swollen area is a root, metamorphosed into a storage organ.

Seed and Fruit. The fruit is an achene, the hard coat being derived from the inner portion of the ovary wall.

Seedling. At germination the cotyledon develops chlorophyll, and the adventitious root of the embryo is the first functioning root.

At first the young seedling is upright, but very soon a horizontal root-stock is developed.

SUMMARY OF RELATIONSHIPS TO OTHER POTAMOGETONACEAE.

On account of the incomplete knowledge we have at present of the members of the Potamogetonaceae, a thorough comparison with them in all points of gross morphology and of anatomy is of course impossible. In the course of this paper I have from time to time alluded to the points of likeness and difference with respect to the remaining Potamogetonaceae, as far as I have been able to glean such from the various articles cited. It is my purpose now to briefly review these here, touching upon the various characters in the order pursued in my paper.

As regards the methods of branching, Cymodocea, Phyllospadix, and Zostera most resemble Ruppia, with a monopodial system in the rootstock and its branches, and a sympodial inflorescent system.

In stem anatomy, perhaps *Potamogeton pectinatus* and *Zostera marina* resemble Ruppia most closely, while Zannichellia and Althenia are also very similar in all respects except that they lack the cortical bundles. The evidence here seems to point to the conclusion that Zostera and Potamogeton are more primitive genera, while, on the other hand, Zannichellia and Althenia are more reduced, with Ruppia somewhere between.

The leaf of Ruppia shows a great similarity in external form to certain species of Potamogeton and to Zannichellia and Althenia. I do not find the secretion cells of the leaf—or indeed of any part of the plant—reported for any but Cymodocea. Posidonia, and Halodule, besides Ruppia. In other points of anatomy, however, the leaf of *Potamogeton pectinatus* is very similar, while the leaves of Zannichellia and Althenia show a strong resemblance, but with absence of the lateral bundles. The natural conclusion based on this evidence is, as stated before, that Ruppia is descended from some form similar to the present submerged Potamogetons, and also that Zannichellia and Althenia are still further reduced.

In the root system, although Ruppia has usually only one root at each node, Zannichellia and Althenia have two, and the Potamogetons several, even *Potamogeton pectinatus* developing four or more (Irmisch, 1858). In Zostera and Phyllospadix a cluster of roots occurs at the nodes. The coleorrhiza has been reported in Potamogeton, Zannichellia, and Cymodocea, and probably occurs also in Althenia and Zostera. In the root anatomy, *Potamogeton pectinatus*, Zannichellia and Althenia correspond closely with Ruppia, as is the case in the other vegetative organs, Zannichellia showing the four distinct meristematic regions at the growing-point as in Ruppia.

Passing to the reproductive organs, where, owing to our lack of information, the comparison is most unsatisfactory, we have seen that the inflorescence is spadix-like, resembling Potamogeton and Zostera, and that the flowers themselves are apparently reduced from some form like Potamogeton.

The archesporium of the microsporangium probably arises in Zannichellia in much the same way as in Ruppia, i. e., originating simultaneously from a large group of cells. Only one species of Potamogeton has been investigated on this point, and here the archesporium is traceable to a single hypodermal cell. Like Ruppia, Zostera also derives tapetum from the outer sporogenous cells, but *Potamogeton foliosus* differentiates it from the wall.

Parietal tissue exhibits a much greater development in the megasporangium of Potamogeton than in Ruppia, and in this respect Zannichellia probably more closely resembles Ruppia. This consideration again points to Potamogeton as the more primitive form. In *Potamogeton natans* (p. 138) an arrangement of the potential megaspores has been found such as occurs in Ruppia.

The pollen-grains of Zannichellia and Potamogeton are more or less globular, those of Ruppia somewhat elongated, while those of Zostera and Phyllospadix have attained extreme length so that they might be termed filamentous. These differences depend presumably on the different modes of pollination prevailing among these genera.

More than any other member of the Potamogetonaceæ so far investigated, the embryo of Zostera has points in common with Ruppia in the manner of its development, and, as is the case with the mature embryo of Zannichellia, resembles it in its mature form. The primary root of Zostera, however, functions for a time during germination.

It will be seen from these considerations that, on the whole,

Ruppia is closer to Potamogeton, Zannichellia, and Althenia than to any others of the Potamogetonaceae, especially with regard to the vegetative organs; and yet, in its embryo, it most strongly resembles Zostera. Similarities in the vascular structure of the vegetative organs are looked upon generally as comparatively fixed indications of relationship; so that in this case the evidence points to Ruppia as being derived from some form similar to the present submerged Potamogetons, with Zannichellia and Althenia serving as examples of still further reduction.

BIBLIOGRAPHY

1. Andrews, F. M., 1895. Development of the Embryo-sac of *Jeffersonia diphylla*. Bot. Gaz. **20**: 423–424. pl. 28.
2. Ascherson, P., 1889. Potamogetonaceae. In Engler and Prantl's Die natürlichen Pflanzenfamilien. **2**[1]: 194–214. figures 152–164. Leipzig.
3. Atkinson, G. F., 1905. A College Textbook of Botany. New York.
4. Bernard, Ch., 1900. Recherches sur les Sphères attractives chez *Lilium candidum*, &c. Jour. Bot. **14**: 118–124, 177–188, 206–212. pls. 4–5.
5. Bornet, E., 1864. Recherches sur le *Phucagrostis major* Cavol. Ann. Sci. Nat. Bot. V. **1**: 5–51. pls. 1–11.
6. Bower, F. O., 1897. Studies in the Morphology of Spore-producing Members. III. Marattiaceae. Phil. Trans. Roy. Soc. London. Bot. **189**: 35–81. pls. 7–11.
7. Britton, N. L., 1907. Manual of the Flora of the Northern States and Canada. Third Edition. New York.
8. Britton, N. L., and Brown, A., 1898. An Illustrated Flora of the Northern United States and Canada. 3 vols. New York.
9. Caldwell, O. W., 1899. On the Life-History of *Lemna minor*. Bot. Gaz. **27**: 37–66. figures 1–59.
10. Campbell, D. H., 1897. A Morphological Study of Naias and Zannichellia. Proceedings of the Cal. Acad. of Sciences. III. Bot. **1**: 1–61. pls. 1–5.
11. —— —— 1898. The Development of the Flower and Embryo in *Lilaea subulata*, H. B. K. Ann. of Bot. **12**: 1–28. pls. 1–3.
12. —— —— 1899. Notes on the Structure of the Embryo-sac in Sparganium and Lysichiton. Bot. Gaz. **27**: 153–166. pl. 1.
13. Caspary, R., 1858. Die Hydrilleen. Jahrb. Wiss. Bot. **1**: 377–513. pls. 25–29.
14. Čelakovský, L. J., 1896. Über den phylogenetischen Entwicklungsgang der Blüte und über den Ursprung der Blumenkrone. I. Sitzber. Königl. Böhm. Gesell. Wiss. 1896[40]: 1–91. figures 1–4.
15. —— —— 1900. Über den phylogenetischen Entwicklungsgang der Blüte und über den Ursprung der Blumenkrone. II. Sitzber. Königl. Böhm. Ges. Wiss. 1900[3]: 1–221. figures 1–30.
16. Chamberlain, C. J., 1905. Methods in Plant Histology. Second Edition. Chicago.
17. Chrysler, M. A., 1907. The Structure and Relationships of the Potamogetonaceae and Allied Families. Bot. Gaz. **44**: 161–188. pls. 14–18.
18. Coulter, J. M., 1898. Contribution to the Life-History of Ranunculus. Bot. Gaz. **25**: 73–88. pls. 4–7.

19. Coulter, J. M., and Chamberlain, C. J., 1903. Morphology of Angiosperms. New York.
20. De Bary, A., 1884. Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns. Transl. by F. O. Bower and D. H. Scott. Oxford.
21. Douliot, H., 1890. Recherches sur la Croissance terminale de la Tige des Phanérogames. Ann. Sci. Nat. Bot. VII. **11**: 283–350. pls. 13–19.
22. Dudley, W. R., 1893. The Genus Phyllospadix. Reprinted from the Wilder Quarter-Century Book. 403–420. pls. 1—2. Ithaca, N. Y.
23. Eichler, A. W., 1865. Zur Entwicklungsgeschichte des Blattes mit besonderer Berücksichtigung der Nebenblatt-Bildungen. Marburg.
24. —— —— 1875. Blütendiagramme. 2 vols. Leipzig.
25. Fischer, A., 1880. Zur Kenntniss der Embryosackentwicklung einiger Angiospermen. Jenaische Zeitsch. Naturwiss. **14**: 90–132.
26. Flahault, Ch., 1878. Recherches sur l'Accroissement terminal de la Racine chez les Phanérogames. Ann. Sci. Nat. Bot. VI. **6**: 1–168. pls. 1—8.
27. Ganong, W. F., 1903. The Vegetation of the Bay of Fundy Salt and Diked Marshes: an Ecological Study. Bot. Gaz. **36**: 161–186, 280–302, 349–367, 429–455. figures 1–16.
28. Goebel, K., 1893. Pflanzenbiologische Schilderungen. Marburg.
29. —— —— 1898. Organographie der Pflanzen. Jena.
30. Griffith, W., 1851. I. Notulae ad Plantas Asiaticas. Part. III. Monocotyledonous Plants. Calcutta.
31. —— —— 1851. II. Icones Plantarum Asiaticarum. Part. III. Monocotyledonous Plants. Calcutta.
32. Grönland, J., 1851. Beitrag zur Kenntniss der *Zostera marina* L. Bot. Zeit. **9**: 185–192. pl. 4.
33. Guignard, L., 1882. Recherches sur le Sac embryonnaire des Phanérogames Angiospermes. Ann. Sci. Nat. Bot. VI. **13**: 136–199. pls. 3–7.
34. Haberlandt, G., 1896. Physiologische Pflanzenanatomie. Second Edition. Leipzig.
35. Hansgirg, A., 1903. Phyllobiologie. Leipzig.
36. Hegelmaier, F., 1870. Über die Entwicklung der Blütenteile von Potamogeton. Bot. Zeit. **28**: 281–289, 313–319. pl. 5.
37. Hillebrand, W., 1888. Flora of the Hawaiian Islands. New York and London.
38. Hofmeister, W., 1852. Zur Entwickelungsgeschichte der Zostera. Bot. Zeit. **10**: 121–131, 137–149. pl. 3.
39. Hofmeister, W., 1861. Neue Beiträge zur Kenntniss der Embryobildung der Phanerogamen. II. Monocotyledonen. Abh. d. K. Sächs. Gesell. der Wiss. **7**: 631–760. pls. 1–25.
40. Holferty, G. M. 1901. Ovule and Embryo of *Potamogeton natans*. Bot. Gaz. **31**: 333–346. pls. 2, 3.

41. Holm, T., 1905. Studies in the Gramineae: VIII. *Munroa squarrosa.* (Nutt) Torr. Bot. Gaz. **39**: 123–136. figures 1–12.
42. Hooker, J. D., 1894. The Flora of British India. VI. Orchideae to Cyperaceae. London.
43. Irmisch, Th., 1851. Über die Inflorescenzen der deutschen Potameen. Flora **34**: 81–93. 1 pl.
44. —— —— 1858. Über einige Arten aus der natürlichen Pflanzenfamilie der Potameen. Abhandl. des naturwiss. Vereines für die Provinz Sachsen und Thüringen. **2**: 1–56. pls. 1–3. Berlin.
45. Juel, H. O., 1884. Beiträge zur Kenntniss der Hautgewebe der Wurzeln. Bihang till K. Svenska Vet.-Akad. Handlingar. **9**^{9}: 1–18. pls. 1–2.
46. Lachmann, P., 1906. Origine et Développement des Racines et des Radicelles du *Ceratopteris thalictroides.* Ann. Univ. Grenoble. **18**^{2}: 1–39.
47. Leavitt, R. G., 1902. The Root Hairs, Cap, and Sheath of Azolla. Bot. Gaz. **34**: 414–419. pl. 16.
48. —— —— 1904. Trichomes of the Root in Vascular Cryptogams and Angiosperms. Proc. Boston Soc. Nat. Hist. **31**: 273–313. pls. 16–19.
49. Magnus, P., 1870. Beiträge zur Kenntniss der Gattung Najas L. Berlin.
50. Massart, J., 1894. La Récapitulation et l'Innovation en Embryologie végétale. Bull. Soc. Roy. Bot. Belgique **33**^{1}: 150–247. figures 1–54. pls. 1–4.
51. Morong, T., 1893. The Naiadaceae of North America. Mem. Torr. Bot. Club. **3**^{2}: 1–65. pls. 1–74.
52. Mottier, D. M., 1895. Contributions to the Embryology of the Ranunculaceae. Bot. Gaz. **20**: 241–248, 296–304. pls. 17–20.
53. Müller, F., 1877. Untersuchungen über die Struktur einiger Arten von Elatine. Flora **60**: 481–496, 519–525. pl. 7.
54. Murbeck, S. V., 1902. Über die Embryologie von *Ruppia rostellata* Koch. K. Svenska Vet.-Akad. Handl. **36**^{5}: 1–21. pls. 1–3.
55. Pechoutre, F., 1902. Contribution à l'Etude du Développement de l'Ovule et de la Graine des Rosacées. Ann. Sci. Nat. Bot. VIII. **16**: 1–158. figures 1–166.
56. Pond, R. H., 1905. The Biological Relation of Aquatic Plants to the Substratum. Report of U. S. Fish Commission **1903**: 483–526. figures 1–6, with tables.
57. Prantl, K., 1883. Studien über Wachstum, Verzweigung und Nervatur der Laubblätter, insbesondere der Dikotylen. Ber. Deutsch. Bot. Gesell. **1**: 280–288.
58. Prillieux, E., 1864. Recherches sur la Végétation et la Structure de *l'Althenia filiformis* Petit. Ann. Sci. Nat. Bot. V. **2**: 169–190. pls. 15–16.
59. Rosenberg, O., 1901. I. Über die Embryologie von *Zostera marina.* Bih. till K. Svensk. Vetensk. Akad. Handl. **27**^{6}: 1–24. pls. 1–2.

60. Rosenberg, O., 1901. II. Über die Pollenbildung von Zostera. Meddel. Stockholms Högsk. Bot. Inst.: 1–21.
61. Roze, E., 1894. Recherches sur les Ruppia. Bull. de la Soc. Bot. de France. **41**: 466–480. pl. 5.
62. Sachs, J., 1875. A Textbook of Botany. English Edition. Oxford.
63. —— —— 1887. Lectures on the Physiology of Plants. English Edition. Oxford.
64. Sauvageau, C., 1889. Contribution à l'Etude du Système mécanique dans la Racine des Plantes aquatiques: Zostera, Cymodocea et Posidonia. Extr. du Journal de Botanique. 1889: 169–181. figures 1–5.
65. —— —— 1891. I. Sur la Tige des Zostera. Jour. de Bot. V: 33–45, 59–68. figures 1–9. (Ref. in Just's Bot. Jahresb. 1891, I, p. 615.)
66. —— —— 1891. II. Sur les Feuilles de quelques Monocotylédones aquatiques. Ann. Sci. Nat. Bot. VII. **13**: 103–296. figures 1–64.
67. Schaffner, J. H., 1896. The Embryo-sac of *Alisma Plantago*. Bot. Gaz. **21**: 123–132. pls. 9–10.
68. —— —— 1897. I. The Development of the Stamens and Carpels of *Typha latifolia*. Bot. Gaz. **24**: 93–102. pls. 4–6.
69. —— —— 1897. II. Contribution to the Life-History of *Sagittaria variabilis*. Bot. Gaz. **23**: 252–273. pls. 20–26.
70. Schenck, H., 1886. Vergleichende Anatomie der submersen Gewächse. Bibliotheca Bot. **1**: 1–67. pls. 1–10.
71. Schilling, A. J., 1894. Anatomisch-biologische Untersuchungen über die Schleimbildung der Wasserpflanzen. Flora **78**: 280–360.
72. Schimper, A. F. W., 1890. Über Schutzmittel des Laubes gegen Transpiration, besonders in der Flora Java's. Sitzb. Akad. Berlin, 1890: 1045–1062.
73. —— —— 1891. Die indo-malayische Strandflora. Bot. Mitteilungen aus den Tropen. **1**[3]: 1–204. pls. 1–7.
74. —— —— 1898. Pflanzengeographie auf physiologischer Grundlage. Jena.
75. Schumann, K., 1892. Morphologische Studien. I. Leipzig.
76. Scott, Daisy G., 1906. The Apical Meristems of the Roots of Certain Aquatic Monocotyledons. The New Phytologist. **5**: 119–129, pl. 9.
77. Scott, D. H., 1894. Recent Work on the Morphology of Tissues in the Higher Plants. Science Progress. **1**: 463–482.
78. Snow, Laetitia M., 1905. The Development of Root Hairs. Bot. Gaz. **40**: 12–48. pl. 1.
79. Solms-Laubach, H. Graf zu, 1878. Über monocotyle Embryonen mit scheitelbürtigem Vegetationspunkt. Bot. Zeit. **36**: 65–74, 81–93. pl. 4.
80. Strasburger, E., 1873. Über Azolla. Jena.
81. —— —— 1879. Die Angiospermen und die Gymnospermen. Jena.
82. —— —— 1882. Über den Bau und das Wachstum der Zellhäute. Jena.

83. Strasburger, E., 1889. Über das Wachstum vegetabilischer Zellhäute. Histol. Beitr. **2**. Jena.
84. —— —— 1891. Über den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen. Histol. Beitr. **3**. Jena.
85. Strasburger, Noll, Schenck u. Karsten, 1908. Lehrbuch der Botanik. Ninth Edition. Jena.
86. Treub, M., 1876. Le Méristème primitif de la Racine dans les Monocotylédones. Leyden.
87. Tyler, A. A., 1898. The Nature and Origin of Stipules. Ann. of N. Y. Acad. of Sci. **10**: 1–49. pls. 1–3.
88. Van Tieghem, Ph., 1870–1871. Recherches sur la Symétrie de Structure des Plantes vasculaires. Ann. Sci. Nat. Bot. V. **13**: 5–314. pls. 3–8.
89. —— —— 1898. Eléments de Botanique. 2 vols. Paris.
90. Vines, S. H., 1898. An Elementary Text-Book of Botany. London and New York.
91. Ward, H. Marshall, 1880. A Contribution to our Knowledge of the Embryo-sac in Angiosperms. Jour. Linn. Soc. Bot. London. **17**: 519–546. pls. 17–25.
92. Warming, E., 1873. Untersuchungen über pollenbildende Phyllome und Kaulome. Hanstein's Bot. Abhandl. **2**[2]: 1–90. pls. 1–6.
93. Warming, E., 1902. Lehrbuch der ökologischen Pflanzengeographie. Second German Edition. Berlin.
94. Watson, S., 1890. Miscellaneous Notes upon North American Plants, chiefly of the United States, with Descriptions of New Species. Proc. of Am. Acad. of Arts and Sci. **25**: 124–140.
95. Wiegand, K. M., 1899. The Development of the Microsporangium and Microspores in Convallaria and Potamogeton. Bot. Gaz. **28**: 328–359. pls. 24–25.
96. —— —— 1900. The Development of the Embryo-sac in some Monocotyledonous Plants. Bot. Gaz. **30**: 25–47. pls. 6–7.
97. Wille, N., 1883. Om Kimens Udviklingshistorie hos *Ruppia rostellata* og *Zannichellia palustris*. Videnskabelige Meddelelser fra d. naturhist. Forening i Kjøbenhavn. 1882–6: 1–14. pls. 1–2.
98. Wylie, R. B., 1904. The Morphology of *Elodea canadensis*. Bot. Gaz. **37**: 1–22. pls. 1–4.

EXPLANATION OF PLATES

Abbreviations. *A* & *B*, primary segments of embryo; *adr*, adventitious root; *ant*, antipodal cells; *as*, axillary scale; *ax*, axillary member; *axb*, axial bundle; *axbr*, axillary branch; *C*, third segment of embryo; *c*, cortex; *cal*, calyptrogen; *cb*, cortical bundle; *cc*, companion cell; *col*, coleorrhiza; *con*, connective; *cot*, cotyledon; *d*, dermatogen; *di*, diaphragm; *e*, egg; *ems*, embryo-sac; *end*, endodermis; *ep*, epidermis; *epc*, epicotyl; *fl*, flower; *fsl*, floral scale leaf; *gen* generative cell; *GP* or *gp*, growing point; *hyp*, hypocotyl; *i*, intercellular space; *ic*, inner cortex; *la*, lacuna; *L* or *l*, leaf; *lb*, lateral bundle; *low. sfl*, lower subfloral leaf; *lpn*, lower polar nucleus; *ma*, male cells; *mc*, middle cortex; *oc*, outer cortex; *pa*, parietal layer or layers; *pb*, periblem; *ped*, peduncle; *pist*, pistil; *pl*, plerome; *pm*, pollen mother-cells; *pr*, primary root cells; *r*, root; *rh*, root hairs; *rha*, rhachis; *rs*, root stock; *s*, sieve tube; *se*, secretion cells; *sfl*, subfloral leaf; *sg*, starch-grains; *sh*, sheath; *spo*, sporogenous cells; *spt*, septum; *st*, stem or stem apex; *sta*, stamen; *stc*, stylar canal; *stg*, stigma; *sti*, stipe; *sus*, suspensor; *syn*, synergidae, *ta*, tapetum; *th*, theca; *tn*, tube nucleus; *tra*, tracheae; *tri*, trichoblasts; *u*, undulations; *upn*, upper polar nucleus; *up. sfl*, upper subfloral leaf; *ust*, upright stem; *vsl*, vegetative scale leaf.

THE NEW YORK
ACADEMY OF SCIENCES.

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 171-236 JANUARY, 1909

Supplement to the New England Spiders

BY

J. H. EMERTON

PUBLISHED UNDER THE AUSPICES OF
YALE UNIVERSITY

NEW HAVEN, CONNECTICUT
1909

WEIMAR : PRINTED BY R. WAGNER SOHN

III.—Supplement to the New England Spiders

by J. H. Emerton.

From 1882 to 1892 the writer published in the Transactions of the Connecticut Academy a series of papers containing descriptions and figures of New England Spiders known to him at that time. The present paper contains additional notes, descriptions, and figures of 48 of these species, partial descriptions, figures and references to descriptions of 38 species described by other persons since 1882, and descriptions and figures of 35 apparently new species.

The portion of New England explored is still chiefly eastern Massachusetts and New Hampshire as far north as the White Mountains. In Maine there have been collections on the coast at Portland and Monhegan, and in the north at Bangor and around Moosehead Lake. Explorations in Canada show the extension northward and westward of many Maine and White Mountain species, as *Theridium zelotypum* to Manitoba, and *Epeira patagiata* and *angulata* to the Pacific coast, and *Epeira carbonaria* and *Lycosa greenlandica* in the Rocky Mountains and Labrador. In the south there have been large collections in Connecticut at Simsbury near Hartford, and at New Haven on the coast, and in Rhode Island near Providence.

The distribution of several species has been made clear by collections on Long Island, N. Y., which is the northern limit of *Oxyopes salticus*, *Pellenes cœcatus*, and *Epeira verrucosa*, and where the following species are found in abundance, that extend northward only as far as Connecticut; *Lycosa scutulata, Acrosoma rugosa* and *Argyrodes cancellatus*. In the western part of Massachusetts, Connecticut, and Vermont but little has been done, but small collections in the Adirondacks and the observations of Mr. Banks around Ithaca, N. Y., show only slight differences from the spider fauna of New England.

The writer has depended chiefly on his own collections, but gives his thanks to G. W. Peckham, Nathan Banks and Miss E. B. Bryant for the use of their specimens and constant help of all kinds.

For references to publications of New England Spiders, the reader is referred to Miss Bryant's list of New England Spiders lately published by the Boston Society of Natural History.

Among the *Epeiridæ, Zilla atrica* is the only additional species found since the publication of New England Epeiridæ in 1884, but the males of the following species are described: *E. corticaria E. Nordmanni, E. juniperi, E. thaddeus.*

The separation of the *Theridiidæ* and *Linyphiadæ* as two distinct families seems to me an improvement, and I have adopted it in this paper, but not the union of the *Linyphiadæ* and *Epeiridæ* into one family, which obscures the marked differences between these two groups. Between certain genera of these families the family differences are hard to define, but the same is true of the differences between genera of the *Theridiidæ* and *Linyphiadæ.*

The *Linyphiadæ* are divided naturally into two subfamilies—*Linyphieæ* and *Erigoneæ*, the former containing the larger long-legged forms, and the latter the smaller forms with short legs and short spines. The genus *Microneta* in the *Linyphieæ* resembles in its form the *Erigoneæ*, and its species are hard to distinguish from those of *Tmeticus.* The most typical species are *viaria, cornupalpis* and *discolor. Microneta* (Bathyphantes) *bihamatus* belongs to this genus rather than *Bathyphantes.* Two new species are described and new specimens have been examined of all the old species except *crassimanus, furcata, longibulbus* and *olivacea.*

In the *Linyphieæ* the principal additions are *Linyphia maculata*, which has been found sparingly in many different localities and described by Banks as *L. conferta Hentz*, and *Tapinopa bilineata Banks*, which has been found singly in several localities.

In the *Erigoneæ* more than in any other group, new species are frequently found, and our descriptions are often made from one or a few individuals. They live for the most part near the ground, hidden in moss and leaves, only small quantities of which can be closely examined, and so little is known about their species and distribution. In their classification they offer many difficulties. Their small size makes their comparison inconvenient, and their uniformity in form and color makes it hard to define their differences. The only characters easy to see and describe are those of the adult males—the organs on the ends of the palpi and the modifications of the head. In consequence of these difficulties, the published classifications consist of a number of ill-defined genera, which have been formed from time to time, as new species were discovered, and the relations of which among themselves have never been satisfactorily explained. In the New England Theridiidæ I used a classification based upon the genera of Menge in the Spiders of Prussia, and in the present paper follow substantially the same, be-

cause it seems to me to show as well as any other the natural relations of the species which I have been studying.

At the beginning of the series come two species which I have described in N. E. Theridiidae under the name of *Pholcomma* at the end of the *Theridiidæ*. *P. hirsuta* belongs to a genus near *Pholcomma*, which Simon in Hist. Nat. Araignées has named *Ancyllorhanis*. It has small mandibles and the pointed maxillæ and the simple male palpi of the *Theridiidæ*. *P. rostrata* belongs to quite a different genus, which Simon has called *Histagonia*, and I have adopted without having seen *H. deserticola*, the type species Another species of the same genus is the *Exechophysis palustris Banks*. *Histagonia* seems to me most nearly related to *Diplocephalus* rather than to *Pholcomma*. The mandibles and maxillæ are like the *Erigoneæ* rather than the *Theridiidæ*, and the modifications of the head and complicated form of the tibia of the male palpi resemble those of *Diplocephalus*. The tarsal hook is present, though small, as it is in *Diplocephalus*.

The new genus *Caseola* with two species *herbicola* and *alticeps* resembles in form and habits *Ceratinella*, but does not have hard pieces on the back and at the base of the abdomen, nor any of the orange color of *Ceratinella*. The male palpi are simple in both species, with a peculiar club-shaped process of the palpal organ directed toward the inner side.

Ceratinella consists of small round spiders, orange-colored or orange brown, with a hard plate on the back of the abdomen in one sex or both. The palpi of the males vary in length, but are all on the same plan, with the palpal organ furnished with a long slender tube turned backward from the distal end of the tarsus toward the base. I consider this genus to include the European *C. brevis* and the American species which Simon separates as the genus *Ceraticelus*, the principal difference being in the sinuous claw of the mandible of *C. brevis*. *Ceratinopsis* consists also of small and brightly colored spiders with usually distinct black markings on the head and sometimes on the palpi and feet. The palpi resemble those of *Ceratinella*, with large and more variable tibiæ. There are no hard plates on the abdomen.

Cornicularia includes species resembling *Ceratinopsis*, but with usually more elongated cephalothorax, and in the males a horn on the front of the head between the upper and lower middle eyes. The male palpi have the tibia enlarged and extended over the back of the tarsus in a long flat process, partly divided into two branches. I include those species which have a double horn on the head,

which Simon refers to *Prosopotheca*, and also, as suggested by Simon, *Spiropalpus spiralis* which, though its male has no horns, resembles this genus.

Grammonata includes, besides the three species before described, *Erigonoplus gigas Banks*, which has lately been found in Massachusetts. All the species resemble *Amaurobius* in form and markings, having an indistinct pattern of light spots on the abdomen. In the males the head is a little elevated behind the eyes, and in *pictilis* and *gigas* there is a conspicuous hump. The males of *gigas* have the first metatarsus white and much thicker than the other joints. The male palpi resemble those of *Ceratinella*, having a long tube turned abruptly backward from the end of the tarsus. In *pictilis* the tube is very long and coiled in a double spiral.

Diplocephalus Bertkau, 1883, is *Lophomma* Em. of N. E. Theridiadæ, in which the males have two humps on the head, each carrying one pair of the middle eyes. The male palpi have the tibia very large, covering the back of the tarsus nearly its whole length.

Lophocarenum consists of those spiders, the males of which, except *rugosum*, have holes in the head behind the eyes, and the middle of the head elevated, sometimes into large humps. The male palpi have the patella longer than the tibia, and the latter usually longer than wide, with small hooks and processes of various shapes. Where the enlargement of the head of the male is extreme, the female has a slight elevation of the head as in *montiferum* and *alpinum*. The unusually large size of the front lateral eyes in *quadricristatum* occurs in a less degree in the female.

There is no better example of the difficulty of classifying the *Erigoneæ* than the attempt of Simon to distribute the American species of this genus, without seeing the spiders themselves, among eight different genera. For *florens* he makes a new genus *Hypselistes*, while *decemoculatum*, the females of which cannot be distinguished from those of *florens*, is placed in *Neriene*, which corresponds in part to my *Tmeticus*. *L. pallidum* and *L. longitubus*, which resemble each other as closely as any other two species, are placed one in *Typhocræstes* and the other in *Pocodicnemis*. *L. scopuliferum* is placed in *Minyriolus*, *L. quadricristatum* in *Panamomops*, *L. longitarsus* in *Lophomma*, *L.* rostratum in *Trachelocamptus* and *L. decemoculatum*, *montiferum* and *spiniferum* in *Neriene*. I see no reason to follow any of these changes; they only obscure the relations of the spiders.

Tmeticus is still a heterogeneous group. The more typical species,

such as *probatus* and *trilobatus*, approach *Erigone* by their wide maxillæ and long palpi and the tibia widened toward the tarsus, and the males have a strong single spine on the front of the mandibles. *Maximus*, *tibialis* and *brunneus* resemble each other in size and proportions, but differ in their mandibles and palpi. The other species have little in common except their general size and color, arrangement of eyes and form of mandibles and maxillæ.

Erigone now includes four species; *longipalpis*, *dentigera*, *autumnalis* and the new *brevidentatus* with wide maxillæ, large mandibles and long male palpi with widened tibia, and a spur directed downward on the patella.

In the *Theridiidæ* there are but few additions. *Theridium kentuckyense* has been found in a few places. The male of *T. zelotypum* is described and the species found to be common in Maine and New Hampshire. *Latrodectus mactans* has been found in several localities, but is nowhere common. The new *Enoplognatha rugosa* has been found rarely but in localities far apart. The same is true of the new *Pedanostethus pumilus*, and *P. spiniferus*.

In the *Agalenidæ*, *Hahnia brunnea* is described from a single specimen, but there is a second one in the collection of Mr. Banks. *Cryphœca montana* appears to be common in northern New Hampshire, and from description is very near the *C. peckhamii* Simon of the Pacific coast.

The larger *Clubionas* have been better defined and new figures are given of the epigynum of several species. The two new species are one from a single specimen *C. spiralis* and the other *C. prematura* a common species from the summit of Mt. Washington, the female of which has long been known as a variety of *C. ornata* Em.

The North American *Lycosidæ* and *Pisauridæ* have been described and their classification much improved by T. H. Montgomery in Proceedings of Philadelphia Acad., 1902–3 and 4. *Lycosa relucens* Montg. is a common species in New England. *Dolomedes idoneus* Montg. and *D. fontanus Em.* have both been described as *D. tenebrosus* Hentz, which agrees equally well with either. The new *D. vernalis* appears to be common in Maine and New Hampshire. *Pirata* remains a difficult group and each author has his own species. *P. minuta* is the most distinct, *montana* and *insularis* have been again identified and three new species are described. In N. E. Lycosidae 1885 I have described under the name of *L. nidifex* what I now consider as two species named by Marx in the Am. Naturalist, 1881. *L. nidifex* and *L. Pikei*. *Nidifex* is the inland species which ordinarily makes a ring or turret at the mouth of its burrow; *Pikei*

is the seashore and sand dune species described by Scudder as *L. arenicola* in Psyche 1877. *L. avara* Keys, *L. baltimoriana* Keys, and *Pardosa littoralis* Banks been have found in New England and new figures and descriptions of them are given.

Since the publication of N. E. Attidae in 1891 the number of species of that family known in New England has been largely increased, but nearly all the species have been described from other parts of the country and appear to have very wide distribution. Some of the most common species are so variable and their differences so hard to define that they are still very imperfectly known, especially in *Phidippus* and *Dendryphantes*. The *Icius* which I described as a dark variety of *elegans* now appears to be a distinct species, *Icius similis*, Bks.

Dendryphantes flavipes Pkm. has been found in small numbers through Maine and New Hampshire. The male is fairly distinct from that of *capitatus* but I cannot distinguish the females. A new species *D. Jeffersoni* is described from very few specimens found on the Mt. Washington range at an elevation of 5,000 feet living in the moss and lichens.

List of New Species.

Enoplognatha rugosa.
Pedanostethus pumilus.
„ *spiniferus.*
Ceratinopsis auriculatus.
„ *alternatus.*
Caseola herbicola.
„ *alticeps.*
Lophocarenum cuneatum.
„ *abruptum.*
„ *minutum.*
„ *rugosum.*
Erigone brevidentatus.
Linyphia maculata.
Bathyphantes calcaratus.
Micronetа denticulata.
„ *serrata.*
Lycosa crassipalpis.
Pardosa diffusa.
Pirata arenicola.
„ *maculata.*
„ *sylvestris.*
Dolomedes vernalis.
Amaurobius borealis.
Micaria laticeps.
„ *quinquenotata.*
Castaneira lineata.
Drassus hiemalis.
„ *bicornis.*
Clubiona spiralis.
„ *prematura.*
Apostenus acutus.
Cryphœca montana.
Hahnia brunnea.
Phidippus Whitmani.
Dendryphantes Jeffersoni.

List of described species found in New England since 1882–1892.

Latrodectus mactans.
Theridium kentuckyense Keys.
Pedanostethus riparius Keys.
Ceratinella formosa Banks.
Grammonota gigas Banks.
Histagonia (Exechophysis) palustris Banks.
Lophocarenum (Dismodicus) alpinum Banks.
„ *(Dicyphus) trilobatus Banks.*
Tmeticus flaveolus Banks.
„ *debilis Banks.*
Tapinopa bilineata Banks.
Zilla atrica Koch.
Pachygnatha tristriata Keys.
Lycosa avara Keys.
Lycosa baltimoreana Keys.
„ *Pikei Marx.*
„ *relucens Montgomery.*
Pardosa littoralis Banks.
Dolomedes idoneus Montgomery.
Dolomedes urinator (Hentz) Montgomery.
Œcobius (Thalamia) parietalis (Hentz).
Scotolathys (neophanes) pallidus Marx.
Orchestina saltitans Banks.
Micaria gentilis Banks.
Prosthesima rufula Banks.
Gnaphosa parvula Banks.
Cicurina pallida Keys.
Phidippus insignarius Koch.
Dendryphantes flavipes Pkm.
Icius similis Banks.
Hyctia Pikei Pkm.
Mævia tibialis Koch.
Pellenes (attus) viridipes Hentz.
„ *(attus) roseus Hentz.*
„ *agilis Banks.*
„ *borealis Banks.*
Homalattus cyaneus Pkm.
Peckhamia (Synemosyna) scorpionea Hentz.

Theridium differens, Em. Trans. Conn. Acad. 1892. (Plate I, figure 7.)

The epigynum of this species is wrongly described and figured in N. E. Theridiidae. The openings are really on the outer side, as they are in *Theridium spirale*, and differ only in being a little smaller and farther apart. See fig. 7.

Theridium zelotypum, Em. Trans. Conn. Acad. 1892. (Plate I, figure 5.)

This species has been found in the White Mountains and all over Maine, as far north as Moosehead Lake, but not south of Portland, Me., and westward as far as Winnipeg, Manitoba. At Monhegan, Me., July 1, 1901 adult males were abundant in webs with the females under spruce branches. The males are as large as the females, and have the abdomen similarly marked. The cephalothorax, legs and palpi are bright orange color, and the legs only slightly darker at the ends of the joints. The dark middle stripe of the cephalothorax is usually shorter than in the female, and does not extend forward to the eyes. The male palpus resembles that of *murarium* with all the appendages more elongated, Pl. 1, fig. 5. At pairing time the webs do not contain the characteristic tents covered with spruce leaves and scales; these are made later and in the last of July and first of August are found in nearly all the webs, hiding the females and eggs. The females remain in the nests with the young as late as September.

Theridium kentuckyense, Keys. Spinnen Amerikas, 1884. (Plate I, figures 6, 6a.)

The same size and general form as *differens* and *murarium*. The colors are less bright than in those species and more like *T. tepidariorum*. The legs are pale, with light yellowbrown, wide rings at the ends of the joints, and less distinctly in the middle. The cephalothorax is brown, darker at the sides, and lightest between the eyes and the dorsal groove, without any stripes. The sternum is brown, without markings, and the coxæ and base of the femora pale.

The markings of the abdomen are distinct at the anterior end and also over the spinnerets, while in the middle they consist of small and indistinct spots in irregular transverse rows extending down the sides. At the anterior end is a bright white spot with a larger black spot on each side sharply defined toward the middle line, and irregular and indistinct at the sides. At the hinder end over the spinnerets is a white spot with short black stripes at the sides. On each side of the abdomen is a short, dark, vertical stripe that in some individuals is deep black.

In the male the markings of the abdomen unite into a more distinct middle light stripe, bordered by two dark ones, but the white spots at the ends are distinct as in the female.

The epigynum is small and rounded behind with two openings twice their diameter apart. The skin is so transparent that the tubes of the epigynum are seen through it and obscure the openings.

At the end of the palpal organ is a long thin appendage, widened and twisted at the end, partly enclosing and supporting the tube. Pl. 1, fig. 6a.

Found at New Haven, Conn., Jaffrey, N. H., and by Dr. Fox at Hollis, N. H.

Latrodectus mactans, Fabr.
Theridion verecundum, Hentz.

This is the largest and most conspicuous species of the family. The abdomen is round, sometimes a centimeter in diameter, and the whole body is deep black except a bright red spot under the abdomen and one or a row of red spots on the upper side. In alcohol the spots fade to white or yellow. In young individuals there is a white line around the front of the abdomen and three rows of spots partly white and partly red along the back, and the legs are brown in the middle of the joints and black at the ends. The adult males are marked much like the young with the lateral spots elongated and with a red line in the middle of each. The males are much smaller than the females, some of them only three or four millimeters long but with long legs. The lateral eyes, which in most Theridiidae are close together, are in *Latrodectus* as far apart as they are from the middle eyes. The epigynum is of the usual Theridion pattern with a single, wide, oval opening partly divided on the front edge. The palpal organ has a very large and long tube coiled in two flat turns across the end of the bulb. In alcohol this tube often becomes displaced and coils around the bulb in any direction.

The nest is usually near the ground under a stone or in a hole in the sod. The web extends among surrounding objects sometimes for a foot from the nest in all directions. It consists mainly of large irregular meshes, but includes usually a distinct flat or curved sheet of smaller meshes like the webs of *Steatoda* or *Pholcus*. The cocoons are half on inch in diameter brownish white in color.

This species is found all over the country as far west as the Rocky Mountains and north to southern New Hampshire. In the South it is common, but in New England occurs only occasionally in scattered localities.

Enoplognatha rugosa, new. (Plate I, figures 8 to 8c.)

Two males sifted from leaves in a swamp in the Blue Hills, May 6, 1905, are about half as large as *marmorata*, measuring 3.5 mm. in length. The cephalothorax is flat and the head wide and low as it is in *marmorata*, but the legs are longer and more slender. The sternum is widest in front, and less indented around the coxæ than in *marmorata*. The mandibles are more slender than in *marmorata*, and the claw is slender and nearly as long as the basal joint. The process on the under side is near the middle, and has a single pointed tip and below it two small teeth, Pl. I, fig. 8c. The legs and mandibles are slightly roughened by little elevations at the bases of the hairs, which are shorter and fewer than in *marmorata*. There are similar elevations on the middle of the cephalothorax and around the edges of maxillæ and sternum. The palpi resemble those of *marmorata*. The color in the specimens examined is pale and less yellow than in *marmorata*, in alcohol inclining to red as in *Steatoda triangulosa*. The abdomen has an indistinct pattern consisting of a broken middle line and two rows of spots.

The female found May 30, 1906, under leaves at Three-mile Island, Lake Winnipesaukee, N. H., resembles the males in color and markings and in size. The abdomen is larger, and the legs and mandibles short as in females of related species. The head, sternum and mouth parts are less roughened, but have longer hairs than in the male. The epigynum has a transverse narrow opening behind, covered by a short brown plate.

Pedanostethus riparius, Keysl. Spinnen Amerikas, Theridiidae, 1886. (Plate I, figures 1 to 1d.)

This species described by Keyserling from Lake Superior, is one of the most common spiders under leaves all over New England.

The length is about 4 mm., the sexes differing little in size. The cephalothorax and abdomen are about equal in length. The cephalothorax is wide in front; about two-thirds as wide as it is at the widest part, and the rows of eyes are almost straight, the upper row only slightly longer than the lower. The palpi of the female are as long as the cephalothorax, and those of the male longer. The maxillæ have the ends straight and nearly parallel, as in *Enoplognatha marmorata*, not oblique as in *Steatoda borealis*. The sternum is as wide as long, widest between the first and second legs and slightly pointed behind. The colors are dull brown and gray, without any markings. The cephalothorax is smooth and shining and darkened a little toward the head. The legs are brown like the cephalothorax, darkened toward the tips and covered with fine hairs. The abdomen is gray, generally lighter than the cephalothorax, and covered with dark gray hairs. The epigynum has a characteristic pear-shaped piece in front, Pl. 1, fig. 1c, but in some individuals this piece is oblong, Pl. 1, fig. 1d.

The male palpi are stout and three-fourths as long as the rest of the spider. The tibia and patella are both short and together equal in length to the tarsus. The tibia is a little narrowed at the base and widened at the end around the base of the tarsus on the outer side. The tarsus is narrow, only partly covering the palpal organ. Near the tip it has a notch on the upper side, and two curved stiff hairs, Pl. I, fig. 1a.

Pedanostethus pumilus, new. (Plate I, figures 2, 2a.)

In the maple swamp at Clarendon Hills, south of Boston, three males have been found of this small species. It is 2.5 mm. long, colored like very light individuals of *riparius*, and resembling it in every respect except in the palpi. These are proportionally shorter than in *riparius*, being not much longer than the cephalothorax. The tibia is more contracted at the base than in *riparius*, and the tarsus is shorter, rounder and thicker. The notch near the tip is wider and there are no special hairs. The female is the same size and color as the male. The epigynum is short like that of *riparius* but has the front piece wider than long instead of pear shaped fig. 2a.

One male also found near the Carter notch, White Mountains, Aug., 1906, and another at Three-mile Island, Lake Winnipesaukee.

Pedanostethus spiniferus, new. (Plate I, figures 3, 3a.)

The male is 2.5 mm. long, and pale like *pumilus*, and resembles it except that the lateral eyes of the upper row are a little farther back. The palpi have the tibia shaped much as in *riparius*, not

as narrow at the base as in *P. pumilus.* The tarsus is oval and less pointed than in *riparius*, with the notch smaller and not as near the tip. At the base of the palpal organ is a long hook turning out at right angle to the tarsus, Pl. I, fig. 13. The female is of the same size as the male. The epigynum is elongated, a third as long as the abdomen. At the front end close behind the fourth coxæ is a small, dark colored, sharp point directed forward a little behind which the round spermathecæ show through the skin, and behind these two parallel dark lines extend backward and meet at the base of a short, pale, blunt appendage directed backward.

This species is found under leaves in company with *riparius* and *pumilus.* Clarendon Hills and Waltham, Mass.

Argyrodes cancellatus. (Plate I, figures 10 to 10c.)
Theridion cancellatum, Hentz.
Lasæola cancellata, Emerton, N. E. Theridiidae. Trans. Conn. Acad. 1882.
Argyrodes larvatus, Keyserling. Spinnen Amerikas.

This species, found in Connecticut, is abundant on Long Island and farther south. It is sometimes found in webs of its own and often in webs of larger spiders, especially in those of *Epeira strix.* The colors are light gray and brown, with silvery spots on the abdomen, and when it is motionless with the feet drawn up, it is hard to distinguish from a piece of leaf or bark dropped by accident into the web.

The female is 2.5 mm. long, with the cephalothorax 1 mm. long. The head is higher, and more vertical in front than in *trigonum* and the front middle eyes project slightly on the front of the head. The lower part of the head is rounded and extends forward a little beyond the mandibles. The abdomen is as high as wide, rounded above and narrowed toward the spinnerets, which are in the middle of the under side. At the end of the abdomen is a double tubercle with the lower half largest, and on each side of the abdomen a little farther forward another tubercle. The epigynum has a wide oval opening, partly covered and divided by a projection of the front edge.

The male is 3 mm. long and the cephalothorax 1.5 mm. The lower part of the front of the head extends forward and downward in front of the mandibles in a nose-shaped process, above which there is a round pit on each side of the head. The abdomen is smaller and narrower than that of the female, and covered above with silvery spots mixed with gray and black. The male palpi are

shorter and have the tarsus larger and rounder than in *trigonum*, Pl. I, fig. 10e. The descriptions and figures are from specimens taken at Cold Spring Harbor on the north side of Long Island, N. Y.

Ceratinella formosa, Banks. Ithaca, 1892. (Plate II, figures 5 to 5d.)

This species was found by Miss E. B. Bryant at Long Island in Portland Harbor, Me., Sept. 11, 1904. It was in great numbers on the stones on the beach and flying by threads in the air. In size and color it resembles *C. læta.* The males have the whole upper surface of the abdomen hard, while the females have only a hard spot across the anterior end. The cephalothorax and abdomen are both longer and less rounded than in *læta*, and the sternum is narrower behind, measuring between the fourth legs one-third its length, while the sternum of *læta* measures half its length. The epigynum has a triangular opening somewhat like that of *læta.* The male palpus resembles that of *C. brunnea*; the process of the tibia is long and hooked, and the tube of the palpal organ is simple, with no tooth at the bend. This species lives among the small stones above high water on the beach, and runs much faster than the other Ceratinellas. Found at Gloucester, Mass. on beaches and one specimen in the Carter notch, White Mountains, N. H.

Ceratinopsis auriculatus, new. (Plate II, figures 9, 9a, 9b.)

1.5 mm. long and much like *C. laticeps.* The colors are yellow and orange like the other species, with a little black on the head and ends of the palpi. The upper middle eyes are more than their diameter apart, and the lateral eyes are farther from them than they are from each other. Each pair of lateral eyes is raised on a little horn turned forward and projecting in a point beyond the eyes. The tibia of the male palpus projects upward and hooks forward. Seen from above it has three indistinct teeth in place of the two long ones of *C. laticeps.*

One male from Three-mile Island, Lake Winnipesaukee, N. H., May 29, 1906, Miss E. B. Bryant; one from Fitzwilliam, July 1907.

Ceratinopsis alternatus, new. (Plate II, figures 6, 6a.)

In general appearance this resembles the female *C. interpres.* The length is 2.5 mm. and the color is light orange brown with black between the eyes, but no other markings. The arrangement of the eyes is the same as in *interpres*, but the head is not quite as high and the back not as straight. The sternum is convex and large, and as wide as long, extending between the fourth coxæ as wide as the coxæ are long.

The epigynum is simple, with a middle lobe a little longer than wide.

The male palpi have the patella long and widened at the end, with a large tooth on the under sider. The tibia is very short and has a tooth on the upper side as long as that on the patella but more slender. The palpal organ has a slender pointed process at the end, and a short and flat basal hook, Pl. II, fig. 6.

Three-mile Island and Jaffrey, N. H., Mt. Tom, Mass., Simsbury, Conn., Balsam, North Carolina.

Caseola, new genus.

General appearance like *Ceratinella*, but without any hard plate on the abdomen. The cephalothorax is as wide as long, in the male *alticeps*, elevated in front. The two rows of eyes are of equal length the upper middle pair as far from the front middle pair as they are from each other. The abdomen is oval, not much larger than the cephalothorax and covered with scattered hairs. The legs are short and differ little in length. The mandibles have three very small teeth on the inner side of the claw groove and two or three larger ones on the front. The maxillæ are longer than wide and a little pointed at the inner corners. The sternum is as wide as long, widest between the first and second legs and extends backward between the fourth legs, where it is as wide as the coxæ. The male palpi have the patella and tibia both short and the palpal organ simple with a slender curved tube, at the base of which is a flat process widened and oval at the end directed outward.

Caseola herbicola, new. (Plate II, figures 1 to 1d.)

1.5 mm. long and resembling *Ceratinella*, but without any hard spots on the abdomen, which is covered with scattered stiff hairs. The color is pale and whitish, without the orange which is usual in *Ceratinella*. The cephalothorax is darkened a little toward the head, and in the male is browner than in the female. The cephalothorax is nearly as wide as long, very little narrowed or raised toward the head in either sex. There is nothing peculiar in the arrangement of the eyes. The front middle pair are as usual smallest and about two-thirds the diameter of the upper middle eyes, with which they make a quadrangle slightly higher than wide. The front row of eyes is almost as long as the upper row, with the lateral eyes a little raised above the head. The mandibles have four or five very small teeth each side of the claw. The sternum

is as wide as long, and extends backward between the fourth coxæ, as wide as the coxæ themselves. The epigynum has a wide transparent lobe in the middle, at each side of which the brown spermathecæ show through the skin, and from which two dark bands curve in half circles toward the middle.

The male palpi are simple with a slender tube curving forward toward a small terminal process with two teeth. Near the base of the tube there is a small dark tooth, and under it, directed toward the inner side, is a pale club-shaped process. The tarsal hook is very small and hard to see. The tibia is widened at the end with no processes or branches, except a slight raised and straight edge on the upper side.

The females have been found in small numbers at several places near Boston under leaves in early spring. Adult males and several females were swept from low plants on Mt. Holyoke, Mass., on June 20th.

Caseola alticeps, new. (Plate II, figures 2 to 2e.)

1.5 mm. long with the general appearance of *Lophocarenum* rather than *Ceratinella.* The males only are known, and they have the head narrow and elevated, somewhat as in *Ceratinopsis interpres.* The eyes are all on the elevation and so are closer together than in *herbicola.* The front middle eyes are only a little smaller than the upper middle pair. The cephalothorax is nearly as wide as long. The abdomen is oval and covered with scattered hairs, which are finer and more numerous than in *herbicola.*

The male palpi have the tibia widened up and down with a tooth on the outer side. The palpal organ is simple, having on the inner side a club-shaped appendage like *herbicola.* The tube ends between two processes at the tip of the organ, one flat and transparent, and the other short and fine, with a peculiar curve at the end. The tarsal hook is very small and easily concealed.

One from Three-mile Island in May, dark colored, and one from Waltham, Mass. in November, which is pale.

Grammonota gigas. (Plate II, figures 8 to 8b.)

Erigonoplus gigas, Banks. Canadian Entomologist. 1896.

Two males of this species were found under a board at Ipswich Bluff, Plum Island, Mass. by Miss Mary T. Palmer, June, 1906. They are 2.5 mm. long and resemble in size and color *G. pictilis.* There are markings on the back of the abdomen as in *pictilis,* but the front half is stained with yellow over the other markings. The

front legs have the metatarsus white and twice as thick as the other joints. The end of the tibia is also slightly thickened. The two middle pairs of eyes are nearly as far apart as the lateral pairs, and the head is slightly elevated between them, and covered with hairs directed backward and upward as in the other species. Behind the eyes is a large hump rising abruptly in front and divided into five lobes. The male palpi resemble closely those of *G. inornata.* The tibia has, on the upper side, a large, simple hook turned forward, and the tube of the palpal organ is short and stiff and turned backward at the tip. This was first found by Banks at Ithaca, N. Y. and described by him in 1896.

Another male was found at Fitzwilliam, N. H., July, 1807, in the rhododendron woods.

Histagonia palustris,

Exechophysis palustris, Banks. Ent. Soc., Wash., 1905. (Plate II, figures 4 to 4f.)

This is another species resembling the *Pholcomma rostrata* described in 1882. It is a little over 1 mm. long, short and rounded like *rostrata,* with the abdomen of the male hard on the back and covered with scattered stiff hairs. The head is elevated and extends forward below the eyes in a blunt protuberance, covered on the end with stiff hairs directed upward and backward.

The male palpi have the tube of the palpal organ coiled once around the end of the bulb. The tibia is flattened and, seen from the side, as wide as long, with a recurved black spine on the distal corner, and a smaller black spine near the basal end, the edge between the two spines irregular and cut into several notches. Seen from above with the palpi in their usual position, the tibia is wedge-shaped with the point directed forward. On the outer side of the tibia near the upper edge are two long hairs, which appear to correspond to the two hairs on the tibia of rostrata.

Three-mile Island, Lake Winnipesaukee, N. H., May 25, 1905. Sifted from leaves. Ithaca, N. Y., N. Banks.

Lophocarenum cuneatum, new. (Plate III, figures 6 to 6c.)

2 mm. long, the cephalothorax dark brown, the abdomen as dark but grayer in color, and the legs distinctly lighter, pale when freshly molted, and light yellow when mature. The cephalothorax is nearly as wide as long, extended in front under the eyes in a blunt point. The head is elevated into a distinct hump, with long oval grooves at the sides, in the front ends of which, close to the

eyes are the lateral pits. The upper middle eyes are on the front and nearly at the top of the hump, the lower middle eyes half way between them and the mandibles. The lateral eyes are wide apart, just outside the lateral grooves, each pair on a slight elevation. The hairs between the eyes are long and pointed outward. The male palpi have the patella nearly twice as long as wide. The tibia is very much widened toward the tarsus and partly covers it on the upper side, where it has a large sickle-shaped hook turned outward. The tarsal hook is flat and broad, with a small notch. The tarsus is short and rounded and the parts of the palpal organ small, with a short tube curved around the end.

A single freshly molted female has the head slightly elevated behind the eyes, and the middle eyes as far from the front pair as they are from each other. The epigynum is very far forward, and has two pointed lobes directed backward and close together with only a narrow groove between them.

Fitzwilliam, N. H. under leaves near the rhododendrons, May 25, 1907.

Lophocarenum abruptum, new. (Plate III, figures 5 to 5c.)

A male a little over 2 mm. long from under leaves on Mt. Holyoke, Mass., June 20. The cephalothorax is depressed in the middle, and the head rises abruptly, carrying the upper middle eyes on the front and upper side. Just above the lateral eyes are wide grooves, with a small round pit a little farther back than the lateral eyes. Between the upper and lower middle eyes are a few fine hairs turned toward the sides. Below the front middle eyes the head projects forward over the mandibles. The tarsus of the male palpus is about half as long as the patella and widened toward the tarsus, and has on the upper side two processes directed forward, the inner one twice as long as the outer and as long as the body of the tibia. The tarsus is rounded and the palpal organ large and thick from above downward. The tube is small and coiled in one turn on the outer side. The colors in this individual are pale, the abdomen darkest.

Lophocarenum quadricristatum. (Plate III, figures 4, 4a.)

This has been found again on the summit of Mt. Washington in August, 1906. The female has in a less degree the same peculiar arrangement of the eyes as the male. The middle pairs are unusually far apart, and the lateral pairs have the front eye one and

a half times as large as the other. The head is a little elevated, highest just behind the upper middle eyes. The epigynum is very simple, showing a straight edge behind, with a wide middle lobe separated only by slight grooves. The sternum in both sexes extends backward between the fourth coxæ, where it is wider than the diameter of the coxæ.

Lophocarenum alpinum, Banks.

Dismodicus alpinus, Banks. Can. Ent., 1896. (Plate III, figures 3 to 3f.)

An adult male and female were found in a thin web under a stone near the summit of Mt. Washington, N. H., and another female and a male not yet molted for the last time under other stones in the same neighborhood. The male is 2 mm. long. The cephalothorax is half longer than wide, narrow in front and extended a little beyond the mandibles. The hump is rounded above and rises between the eyes and the middle of the cephalothorax; it is nearly as wide as the front of the head, and inclines forward a little over the eyes. The front of the hump is covered with short hairs, longest below and turned outward toward each side. On each side of the hump at the level of the eyes is a groove with a round pit at the front end. The eyes are spread over the whole width of the head, the lateral pairs largest, the front middle pair very small and near together. The eyes of the upper row are equal distances apart. The palpi are longer than the cephalothorax. The tibia is shorter than the patella, and extended only a little over the upper side of the tarsus, where it is divided into two teeth, the inner one longest but slender and hooked inward at the end. The palpal organ resembles that of the last species and of *L. montiferum.*

A young male almost ready for the final moult, shows a small hump behind the eyes and a slight extension of the front of the head. The palpi are much enlarged, and show the form of the male tibia and palpal organ indistinctly through the skin.

In the female which is about the same size as the male, the front of the head is not extended forward, but there is a slight hump one-fourth as high as that of the male, in the same place between the eyes and the middle of the cephalothorax. The epigynum has a wide middle lobe curved on the edge and shows through the skin the spermathecæ and two irregularly coiled tubes at the sides of the middle lobe.

Lophocarenum trilobatum. (Plate III, figures 1, 1a.)
Dicyphus trilobatus, Banks. Canadian Entomologist, 1896.

One male only from the maple swamp at Clarendon Hills, about the same size as *L. montiferum*, with a hump as high as that species, but differently shaped. The cephalothorax is not quite as wide as long, and a little narrower in front. The eyes are grouped together as in most species, the hinder middle pair a little farther apart than they are from the lateral and the lateral pairs almost horizontal. The hump is half as wide as the cephalothorax and nearly of the same height. It is rounded behind and in front divided into three lobes, the middle one extending forward nearly to the eyes. The palpi are longer than the cephalothorax, the tibia a little shorter than the patella, but elongated over the tarsus on the upper side, so that it appears longer. This process of the tibia is divided into two teeth, the outer one longer and larger than the inner. The palpal organ has some resemblance to that of *montiferum*, with a small tarsal hook and the tube curled once around the end.

Lophocarenum minutum, new. (Plate III, figures 8, 8a, 8b.)

1 mm. long and light yellow brown. The cephalothorax is one-fourth longer than wide and rounded in front. The head is only slightly elevated, and the lateral grooves are behind the eyes, with the pits showing from above through the skin one-third the length of the cephalothorax from the front. The sternum is as broad as long, extending backward between the fourth legs, where it is as wide as one of the coxæ. The palpi have the patella and tibia both short, about as wide as long. The tibia is a little widened toward the tarsus and has on the upper and outer side a short, fine and slightly curved tooth. The tarsal hook is long and slender, and in my specimens turns outward so that it shows from above. The palpal organ is small and simple, and there is a short and blunt black process that extends beyond the end of the tarsus. The tarsus is slightly angular on the outer side. The female has the head slightly lower, with the upper and lower middle eyes closer together. The epigynum resembles that of several other species of the genus having a distinct middle lobe, widened at the end in front of which are two openings.

Fitzwilliam, N. H. under leaves near the rhododendrons, May 25, 1907.

Lophocarenum rugosum, new. (Plate II, figures 3 to 3g.)

2 mm. long. The cephalothorax is oval, widest across the middle and highest behind the eyes. The surface is slightly roughened all

over. The sternum is also rough. It extends backward between the fourth legs, where it is wider than the coxæ. It extends also between the first and second, and between the second and third legs. The maxillæ are wider than long, and the mandibles stout, with four teeth on the front of the claw, and three small and one large one on the inner side. The eyes spread across the whole front of the head. The front row is straight, with the middle pair smallest, and the middle quadrangle is higher than wide. The abdomen is round and a little pointed at the spinnerets as in Erigone. The abdomen is covered with short and fine scattered hairs. The coxæ are long, extending beyond the border of cephalothorax, so that all are visible from above, and the legs are long and stout and covered with coarse hairs.

The epigynum is very far forward and has a light colored middle lobe, longer than wide, at the sides of which the spermathecæ show through the skin.

The palpal organs are very simple; the tube and two short appendages showing only at the distal end. The tarsal hook is small and the tarsus short and round. The tibia is widened a little across the middle, and has a flat extension with a straight edge against the upper side of the tarsus.

The relations of this species are doubtful as the male does not have the grooves and pits in the sides of the head which are characteristic of the males of most species of this genus. In other respects, however, its resemblance is close to *L. latum* and *L. crenatum* and still more to an undescribed species from Long Island, N. Y., for which the females are easily mistaken. The sternum in all of these is wide and convex and roughened all over the surface. The extension between the legs occurs in the same way in *L. crenatum.* The form of the epigynum is the same in all four species. The resemblance of the male palpi is equally close, all the species having the tarsus nearly of the same shape and the parts of the palpal organ small and with only slight variations among the species.

Grafton, Mass. Three-mile Island, Lake Winnipesaukee, N. H. under leaves.

Tmeticus longisetosus, Emerton. Trans. Conn. Acad. 1892. (Plate IV, figure 9.)

This species has been found again in March, 1907, under leaves in Allston, near Boston. The male and female are of the same size and much alike. They are pale in color, the legs and cephalo-

thorax light yellow tinged, when fresh, with light red on the head and mandibles. There is a row of four or five hairs directed forward on the middle line of the head. The abdomen is covered above and below with scattered hairs about their length apart. The mandibles of the male have a strong tooth in front. The sternum extends backward between the fourth coxæ and is truncated at the hinder end, where it is about half as wide as the fourth coxa. The epigynum appears very simple externally, showing two small spermathecæ through the skin, over which the short scattered hairs are arranged in two clusters. The male palpi have been sufficiently figured in N. E. Theridiidæ.

Tmeticus flaveolus, Banks. Proc. Acad. Nat. Sci. Phila., 1892. (Plate IV, figures 8, 8a, 8b.)

This species resembles *T. longisetosus* in size and color. It is 1.5 mm, long. When fresh the cephalothorax is light orange color and the rest of the body pale. The sternum extends backward beyond the fourth coxæ, where it is as wide as one of the coxae. The mandibles of the male have a small spine on the front near the end. The epigynum is much like that of *longisetosus*, with a transverse slit with the spermathecæ showing through the skin. The male palpus resembles that of *longisetosus*, but the tibia and tarsus are both slightly shorter. The tibia is widened at the end as it is in *longitarsus*, with several projections and shallow curves on the edge. The tarsus has two large spines near the base, one much thicker than the other and both about half as long as the corresponding spines in *longisetosus*.

Coffin's beach, Gloucester, Mass., in straw on the shore. Hanover, N. H. and Ithaca, N. Y. in Mr. Banks' collection.

Tmeticus debilis, Banks. Proc. Acad. Nat. Sci. Phila., 1902. (Plate IV, figures 3, 3a, 3b.)

2 mm. long, and pale yellow, brown and gray, with some individuals almost white. The group of eyes is rather narrow, not more than half the width of the thorax. The sternum is widest at the second legs, and extends between the fourth coxæ in a narrow piece not more than half the diameter of one of the coxæ. The male palpi are large and the palpal organs of a very distinct form. The tibia is small, but widened at the end, where it is about twice as wide as at the base. The tarsus is long and oval, with a smooth strip without hairs near the outer edge. The tarsal hook is slender and has a short rounded process near the base on the outer side.

All the appendages of the palpal organ are long and slender. The tube itself starts at the base under the tarsal hook and extends more than half around the tarsus, and is supported through nearly its whole length by a stouter process with a long hook at the end, usually dark-colored and having a short tooth near its base on the inner side of its curve. At the base of this stout process is another about half as long; which is soft and white and ends in a blunt point near the tip of the tube.

Hammond's Pond woods, Brookline, Carlisle Pines.

Tmeticus corticarius, new. (Plate VI, figures 4, 4a, 4b.)

This species had only been found singly in Cambridge and in New Haven, Conn., until trees around Boston and Providence were banded with cloths to trap the Gypsy moth caterpillars in 1905. It then appeared in considerable numbers under these cloths in both places from July until October.

The length is 2.5 mm., the males and females being of the same size, the males having only slightly longer legs and smaller abdomen. The color is dull gray, the legs and cephalothorax yellowish, and the abdomen almost black. The front of the head is narrow and rounded, and the eyes not far apart. The epigynum is three-lobed, the outer lobes forming part of a semicircular plate a third as wide as the abdomen. The male palpus has the tibia very short and extended upward and downward. The upper process is very conspicuous when the palpus is seen from the side. It is half as long as the tarsus, and curves slightly forward so as to fit the tarsus if both are brought together.

Tmeticus brunneus, Em. Trans. Conn. Acad. 1882. (Plate IV, figures 7, 7a, 7b.)

This has been found again on Mt. Washington by Mrs. Slosson, and is in Mr. Banks's collection. It is closely related to *T. tarsalis* and *T. maximus,* especially the latter; the upper projection of the tibia, however, is distinctly more pointed and larger than in *maximus,* and the tarsal hook is longer. The epigynum is also longer and projects more from the surface of the abdomen than in *maximus.*

Erigone brevidentatus, new. (Plate II, figures 10b, 10c.)

A small species not much over 1 mm. in length. The colors are the usual brown and gray, rather pale in all three specimens. The cephalothorax is only a little elevated behind the eyes, and there are no spines around the edge. The mandibles have one long

spine on the inner side and seven on the outer side, the longest one being opposite the one on the inner side. The male palpi have the patella and tibia of nearly the same length. The usual tooth on the under side of the patella is very small and short.

Mt. Holyoke, sifted from leaves June 20, 1906; Fitzwilliam, N. H., July 20, 1907.

Linyphia maculata, new.

Linyphia conferta (Hentz) Banks, 1892. (Plate IV, figures 10 to, 10 g.)

This species is related to *clathrata* and *mandibulata.* The abdomen is high behind as in those species, and sometimes extends backward beyond the spinnerets. The cephalothorax of the female is somewhat shorter and the legs longer than in *clathrata* and *mandibulata.* The hinder middle eyes are farther apart than they are from the lateral eyes. The front middle eyes are small and less than their diameter apart.

The cephalothorax and legs are light orange yellow, the cephalothorax a little darker, and the eyes are surrounded by black. The abdomen is pale in front and marked with several dark spots, the front ones in pairs, which toward the hinder end are sometimes almost black. Around the sides of the abdomen are gray spots and a row of irregular opaque white spots. In the male all the colors are darker, and the abdomen sometimes almost black. The sternum and under side of the abdomen are brown without any markings.

The epigynum is widened toward the hinder end, Pl. IV, fig. 109. The palpi of the males have the tarsi and palpal organs black, the palpal organs large and complicated and resembling those of *L. marginata.*

At the time of publication of the N. E. Theridiidæ I had seen only the young of this species at New Haven, Conn. In 1883 an adult male was found at the same place, and one near Boston in 1890. More lately they have been found to be common near Boston, at Ipswich, in the Blue Hills, and at Sharon, living in webs near the ground like *L. mandibulata* but preferring more shady situations under the trees and bushes along paths through the woods rather than open meadows. The webs are large and nearly flat, but the part on which the spider usually stands is sometimes a little raised by tighter threads from above.

Tapinopa bilineata, Banks. Journal New York Entomological Soc., 1893, p. 128. (Plate XII, figures 8 to 8 f.)

This species has been found twice, at Woods Hole in 1883, and at Clarendon Hills, south of Boston, in 1904, under leaves in winter in a maple swamp, both specimens females. The male was found in 1906 at Portland, Me.

The length is 5 mm. and the length of the cephalothorax 2.5 mm. The cephalothorax is one half longer than wide, and the projecting middle eyes and the black bands narrowing toward the front make it appear longer and more pointed at the head than in the nearly related species. The middle eyes of the front row are as large as those of the upper row, which is unusual in this family, and the four middle eyes form a quadrangle longer than wide and nearly as wide in front as behind. The front middle eyes project forward over the mandibles. The mandibles are wide in front, with long claws and have seven teeth in front, the middle one-half the diameter of the mandible in length. On the under side of the mandibles are five or six shorter teeth, Pl. XII, fig. 8 d.

The abdomen is shaped as in *Linyphia phrygiana* and *Bathyphantes nebulosa,* high in front and low and pointed behind.

The colors are translucent, white and black or dark gray, all becoming yellow in alcohol. The cephalothorax has two wide black bands at the side that cover more than half its surface, leaving a middle light band narrowing behind and toward the front. The dark bands do not quite extend to the sides of the head or much below the eyes in front. The back of the abdomen is marked with a series of pairs of dark spots, in one specimen united on the posterior half, so that half of the back is entirely black. The legs have wide dark bands around the ends and middle of the longer joints. The sternum is gray, darkest at the sides and the coxæ are gray at the outer ends.

The epigynum is curved downward in a half circle and widened at the end, Pl. XII, fig. 8 f. At the base it is as wide as long, with an opening at each side and a thin partition in the middle, Pl. XII, fig. 8 e.

The markings are more distinct, and darker than in the European *longidens,* of which there are specimens from Germany sent by A. Menge of Danzig in the Museum of Zoology at Cambridge.

The male resembles the female, except that the legs are longer, and the top of the head above the eyes more hairy. The male palpus resembles that of *T. longidens*: the tarsus has a long tooth near the base on the upper and inner side which is curved backward, but is not divided at the end into two teeth as it is in *longidens.*

Bathyphantes calcaratus, new. (Plate IV, figures 13, 13a.)

This species has been found at Portland, Maine, Moosehead Lake, and the lower part of Mt. Washington. The largest measures 3 mm. long. All the specimens are distinctly marked with gray, the darker one resembling *Drapetisca socialis.* The legs are long and slender, the femur darker toward the tip, and the tibia and metatarsus dark at the end and in the middle. The cephalothorax has a dark spot in the middle, wide in front and tapering to a line behind. The abdomen is white and gray, the markings of the front half united into a middle stripe with broken edges and two narrow lateral stripes. On the hinder half the markings are in pairs, slightly connected in the middle. The male palpi are as long as the cephalothorax. The patella and tibia are both short, but the tarsus is elongated with a short and sharp spur at the base. The tarsal hook is very large, recurved and widened at the end, where it has a short point above, and a longer one below, as shown in the figure. The tarsal hook resembles that of *Microneta crassimanus,* a larger and shorter legged spider.

Microneta persoluta. (Plate IV, figures 11, 11a.)

The old figures in N. E. Theridiidæ do not give a correct idea of the form of the tarsal hook, though they do show its characteristic sinuous lower edge. The tarsal hook is turned outward and thickened at the end, where it has several blunt irregular teeth as shown in the figure. It has been found at several new localities and seems to be a common species.

Microneta denticulata, new. (Plate IV, figure 14.)

This species resembles closely *M. persoluta* in size and color, and is found in company with it, but is easily distinguished by the palpi, Pl. IV, fig. 14. The tarsal hook is nearly horseshoe shaped and has a thick edge on which are six or moreprominent teeth, those near the base partly united. The parts of the palpal organ are longer and more separate than in *persoluta.* The mandibles are without a prominent tooth on the front.

Microneta latidens, Emerton. Trans. Conn. Acad., 1892. (Plate IV, figures 12 to 12c.)

The male of this species was described in 1882 from New Haven, Connecticut. Since that time both sexes have been found at several places and in large numbers. It is 2 mm. to 2.5 mm. in length, the females being usually a little smaller than the males. The

general color is gray, paler on the legs, and there is great difference in the depth of color in different individuals. In alcohol the wetting of the hairs makes them paler and more translucent, and they soon become yellow. The abdomen is marked with four longitudinal lighter lines partly broken into spots. There are no markings on the cephalothorax, except a little black around the eyes.

The epigynum is not folded, but extends backward half way to the spinnerets, curved slightly inward toward the body and outward again at the tip, Pl. IV, fig. 12d.

The male palpi have the tibial hook large and wide, turning outward with three teeth on the thickened edge. The base of the tarsus has a slight horn, shorter than in *viaria*. The end of the palpal organ has two small black processes, one twice as long as the other, Pl. IV, fig. 12a, which show from below when the palpi are held in the usual position.

Micronetа serrata. (Plate IV, figures 15, 15a, 15b.)

One male from a fence in Boston, Nov. 20, 1900, during the autumn flight. Length 1.5 mm. The cephalothorax is a third longer than wide, and narrowed toward the front. The eyes cover the whole front of the head and are large for the size of the spider. The front middle eyes are only slightly smaller and closer than the upper middle pair. The cephalothorax is highest in the middle where it is more than half as high as wide. The sternum is large and convex, widest in front, and ending in a blunt point between the fourth coxæ.

The male palpi are very peculiar. The patella is as long as wide; the tibia is twice as long as the patella and a little widened at the end, with a thin projection on the outer upper corner, extending forward and turned a little inward. There is a little ridge on the back of the tarsus parallel to this process. The tarsus has a slight spur at the base. The tarsal hook is slender as in several small *Bathyphantes*. The middle appendage of the palpal organ is larger than in *Micronetа viaria* and has on the outer side a line of short black spines, Pl. IV, fig. 15a.

Epeira angulata, Clerck.
E. silvatica, Em. N. E. Epeiridæ. Trans. Conn. Acad., 1884.
E. solitaria. N. E. Epeiridæ. Trans. Conn. Acad., 1884.
E. nigra. Canadian Spiders. Trans. Conn. Acad., 1894.

Comparison of several specimens from western Canada leads me to think that *silvatica*, *solitaria* and *nigra* are all varieties of *angu-*

lata. In New England this species continues to be rare, but in the Rocky Mountains and in Oregon and California it is common on fences and outside of houses. On the piazza of hotels through the Canadian Rocky Mountains, the males vary in size from that of *solitaria* with the cephalothorax 5 mm. in length, to the smallest *silvatica* only 3.5 mm. The length of the first femur varies in these specimens from 5.5 to 4 mm. Four males from the hotel at Glacier varied among themselves nearly as much. The palpi of the larger specimens resemble *solitaria* and *nigra*, with the tube curved upward at the base and strongly curved toward the end, while in smaller, light-colored individuals, the tube is less curved, lies closer to the bulb and tapers more regularly toward the point, as in the smaller *silvatica*. The shape of the second tibia is the same in all the varieties, the spines being somewhat longer and stouter in larger individuals.

The females vary but little, except in color, most of the western specimens being darker than those from New England. The shape of the epigynum is very uniform, with the finger very long and slender.

In August, 1906, Mrs. Annie Trumbull Slosson found a male on the hotel at the summit of Mt. Washington that resembles very closely the original *E. solitaria* from Massachusetts.

Epeira corticaria, Em. New Engl. Epeiridæ, 1884. (Plate V, figures 3, 3a.)

Mature males and females are found on the lower part of Mt. Washington, N. H., in the early part of August. The females have the finger of the epigynum broken off or shrivelled. The males are marked and colored like the females, except that in the males the dark stripes at the sides of the cephalothorax are wider, and the dark rings of the legs more distinct. The second tibiæ are slightly thickened and curved, and five spines on the upper side and two on the inner side are thickened and dark-colored. There are no spines on the coxæ.

Epeira Nordmanni, Thorell.

A male from The Glen at the base of Mt. Washington, N. H. is 9 mm. long, the cephalothorax 5 mm. The dark stripes at the sides of the cephalothorax are wider and more definite than in the female. The markings of the abdomen are like those of the female, but are less distinct. The second tibiæ are slightly thickened and

curved, and the spines on the upper and inner sides stout and dark-colored. There are no spines on the coxæ.

Epeira thaddeus, Hentz. (Plate V, figures 2, 2a.)

The males I have seen, from Sharon and Waltham, Mass., are a little smaller than females from the same places. The front leg is much elongated, the patella and tibia together being as long as the spider from eyes to spinnerets. The usual little process on the anterior end of the first coxa is lengthened into a spine directed forward about half the diameter of the coxa in length. The second leg is slightly thicker than the first; the tibia is a little curved, and the four spines on the inner side are stouter but not shorter than the others on this joint. The color is pale, without any bright orange on the legs or dark brown around the abdomen common in females. The first and second legs have brown rings at the ends of the joints, while the third and fourth have the dark ends of the joints less strongly marked than in females. The cephalothorax is pale, with a pale gray stripe in the middle. The abdomen does not have the brown band around the sides which is so characteristic of females, and on the back it is marked with pairs of bright yellow spots, the two anterior pairs larger than the others, somewhat as in *E. globosa.* Some females have similar markings on the back of the abdomen.

Epeira juniperi, Em. (Plate V, figures 1, 1a.)

Two males swept from bushes at Ponemah, N. H., were slightly greenish on the abdomen, which is striped with white at the sides and across the front. The rest of the body was pale and yellowish. The ends of the tibiæ of first and second legs were light orange, covering nearly half the joint, but not forming a definite ring. The cephalothorax is nearly as wide as long and 2 mm. in length. The legs are long and slender, the tibia and patella of the first pair measuring 3 mm. The spines of the legs are dark colored and very long, especially on the tibial joints; those on the first tibiæ being half as long as the whole tibia. There are no modifications of the second tibia.

Epeira labyrinthea, Hentz.

Hentz, in his description of this species, says that a tube, similar to that of Agalena, leads from the web to the nest. I have never seen such a tube; but often there are several threads, as in *Zilla atrica,* leading from the center of the round web to the nest, and

the center is drawn tight by them, giving the appearance of a funnel-shaped opening to a tube. There is, however, no hole in the center of the web, and the cluster of threads may be flat or slightly depressed in the form of a gutter.

Zilla montana. (Plate V, figure 4b.)

This is a common house spider at Deer Island and at northern end of Moosehead Lake, Maine, making its nests like *Z. atrica* under the edges of clapboards. In North Carolina it lives on houses and in bushes at the summit of Roan Mountain, and in houses and barns at the base of the mountain, near the railroad.

Zilla atrica, Koch.

Eucharia atrica, Koch. 1845. (Plate V, figures 4 to 4d.)

In size and color this resembles the other species. The markings of the back of the abdomen resemble closely those of *x-notata,* but the middle of the back is usually lighter, and the two diverging dark marks near the anterior end are longer and narrower than in *x-notata.* The cephalothorax has a more distinct dark middle stripe than in the other species. In the males the palpi (fig. 4a) are twice as long as the cephalothorax, and about twice as long as those of *x-notata.* The front legs of the male are, however, one-eighth shorter than those of *x-notata,* the front tibia and patella measuring a little less than twice the length of the cephalothorax. The form of the epigynum is shown in fig. 4b in comparison with those of *x-notata* and *montana.*

The webs are like those of other species with a large central spiral from which a strong thread extends to the nest. A large segment opposite this thread is usually left open, but is often partly or entirely closed. Adults are found from August until winter.

First noticed by McCook at Annisquam, Mass., about 1885, and now found abundantly at Ipswich, Gloucester, Salem, and Lynn, where it lives in hedges and on the outside of houses, making tubular nests open at both ends under the edges of the clapboards. At Ipswich, I first noticed them on a new cottage near the shore far from any other house, in 1900. At that time there were none of them on other cottages in the neighborhood or on the old farmhouse at Lakeman's beach. In 1904 they were on all the neighboring houses and barns and in the liliac bushes around them.

Tetragnatha vermiformis, Em. N. E. Epeiridae.

Positions of male and female while pairing. Fresh Pond marshes

Cambride, Mass. Sept. 3. 1901, 8 a. m. in irregular net on marsh-grass (Pl. V, fig. 5.) Position of mandibles while pairing (fig. 5a.).

Pachygnatha tristriata, Keysl. 1882. (Plate V, figures 6 to 6d.)

This species is not the same as *brevis.* The size is about the same as *brevis,* but both the cephalothorax and abdomen are slightly longer and narrower. The cephalothorax has three stripes in both species, but the abdomen of *tristriata* has the dorsal marking with straight black edges instead of scolloped as in *brevis.* The four middle eyes are raised above the head with the upper pair higher than the top of the cephalothorax, while in *brevis* the eyes are lower than the highest part of the cephalothorax. The cluster of middle eyes is as far above the mandibles as it is high. In *autumnalis* the upper middle eyes are larger than the others and farther apart, and the cluster of middle eyes is much higher than it is distant from the mandibles. In males the differences are more distinct than in females. The male palpi of *tristriata* have the tarsus and palpal organ longer and more slender than in *brevis,* the bulb is narrower, and the tube and narrow end of the tarsus are twice as long as they are in *brevis.* The tarsal hook of *tristriata* is straighter and more slender than in *brevis.*

Orono, Me., Salem, and Gloucester, Mass.

Lycosa avara, Keys. Zool. bot. Ges. Wien, 1876.

L. rufiventris, Banks. (Plate VII, figures 2, 2a.)

This spider resembles very closely *L. pratensis.* The light stripe on the cephalothorax widens behind the eyes, and has a middle dark line and a broken dark line each side of it as in *pratensis.* The front row of eyes, which in *pratensis* is straight, has in *avara* the lateral eyes a little lower than the middle pair. The eyes of the second row are a little larger than in *pratensis,* so that it appears slightly longer than the first row, while in *pratensis* it is slightly shorter; the difference is, however, too small to measure and cannot be seen in all specimens of *pratensis.* The two specimens of *avara* examined vary in size as does *pratensis.* The most distinctive character of *avara* is the form of the epigynum as shown in fig. 2. At first sight it shows a pair of round holes, and it is only by rubbing away the hairs that the shape of the middle lobe can be seen. This is anchor-shaped with the pointed ends curved around so that they point directly forward. There is a slight projection in the middle. At the front end the middle lobe widens, and its edges are continuous with the anterior borders of the two large holes.

Two females were found by Miss E. B. Bryant, one in Allston, Mass., and the other at Long Island, Portland, Maine.

Lycosa frondicola, Em. N. E. Lycosidæ.

L. nigroventris, Em. is the male of this species.

This species and *L. Kochii* are often found in the same localities. They both mature late in autumn and carry their cocoons of eggs in May. *Frondicola* is darker brown and less mottled than *Kochii.* The middle stripe of the cephalothorax is straight in *frondicola* and notched at the sides in *Kochii.* The young of *frondicola* are more mottled on the legs than the adult and resemble the young of *L. cinerea.* The *L. nigroventris* described in N. E. Spiders is an unusually large male *frondicola.* The male is usually two thirds the size of the female with the under side darker. The legs are lighter and the markings on back of abdomen more distinct.

Lycosa carolinensis, Hentz.

Mr. W. L. W. Field of Milton, Mass., has watched for many seasons a large number of these spiders in a pasture on a gravelly hillside, where they make holes six or eight inches deep, sometimes straight and sometimes curved irregularly, to avoid large stones. Sometimes the mouth of the hole is funnel-shaped, spreading to twice the diameter of the lower part of the tube. The males appear only in the late summer, and the fertilized females winter in the tubes which are closed partly by the wheather, and lay their eggs in the last of May or June. In the summer the half-grown spiders are sometimes found without holes, and they have been known to abandon their holes and make new ones.

Lycosa baltimoriana, Keys. Zool. bot. Ges. Wien. 1876. (Plate VII. figures 1, 1a, 1b.)

This is a large and distinctly marked species, the female 15 mm. long, the cephalothorax 8 mm. long, and 5.5 mm. wide. The eye area is small, occupying one-third the width of the head and one-sixth the length of the cephalothorax. The front and second rows of eyes are of the same length. The legs are of moderate length, as in *carolinensis* and *tigrina.* The general color is gray like *carolinensis* with black markings. The cephalothorax has indistinct dark radiating lines. The back of the abdomen has a dark spot following the shape of the heart, and behind it two or three irregular triangular spots, and along the sides are other irregular markings. On the under side of the abdomen is a square black

spot extending from the lung openings back nearly to the spinnerets. The sternum is black. The legs are marked with broken dark rings.

The epigynum is narrow in front with two small openings; it is widened in the middle and has a small T-shaped end behind, Pl. VII, fig. 1b.

The male palpus is much like that of *L. nidicola* fig. 1e, which is from a specimen from Providence, R. I. belonging to Mr. Banks.

From Woods Hole, Mass., and Simsbury, Conn.

Lycosa Pikei, Marx. American Naturalist, 1881.

L. nidifex, Em. N. E. Lycosidae.

L. arenicola, Scudder. Psyche, Vol. II, 1877, name preoccupied by Cambridge in Spiders of Dorset. (Plate VII, figures 3d, 3e.)

The burrows of this species do not usually have a tube of straw or other rubbish around the mouth. The edge of the tube is thickly covered with silk, which extends out sometimes an inch around it on the surface of the sand. In digging, the surface of the sand is first covered thinly with silk. A ball of sand held together by the silk is then gathered up and carried to the mouth of the burrow in the mandibles; there, without the spider coming out of the hole, it is placed on the ends of the front legs, and thrown as far away as possible. In full grown spiders this is about two inches, and the balls of sand may sometimes be seen in a circle of this radius around the hole. When looking for prey, the spider sits with the cephalothorax and front of the abdomen out of the hole and the feet turned under the body as if dead. A step on the sand within ten feet will alarm them and they disappear down the burrow, but by creeping slowly without jarring the ground or throwing a shadow over the hole, one may get within two feet of the spider without disturbing it. The spider will notice an insect moving six or eight inches away and will rush out and catch one at that distance, returning quickly with it to the burrow. The adult males live part of the time in holes like females, and lie out at the top and wait for insects in the same way, but in August and September they are often found wandering. A male confined over night and then turned loose near the burrow of a female at once looked into it, reaching down its whole body except the tip of the abdomen and the fourth legs. It quickly came out, followed to the mouth of the burrow by the female who at once went down again, and returning in a few seconds, seated herself in the usual position over the edge of the hole. The male then approached slowly with the front of

the body raised, alternately reaching forward the front legs and jerking them quickly back until almost near enough to touch the female. She then came toward him and struck at him weakly with her front legs, but he turned them aside, jumped on her back and tried to place his palpus under her. She then attacked him in earnest and drove him away, afterward going down in her burrow and remaining there, and the male soon wandered away.

Young an eighth of an inch in length are found in small burrows of their own from June to August, and in holes with adult females as late as Aug. 10.

Lycosa nidifex, Marx. American Naturalist, 1881. (Plate VII, figures 3 to 3e.)

In N. E. Lycosidae I have confounded this species with *L. pikei*, under the name of *nidifex*.

This inland species differs distinctly from *Pikei* and approaches *L. missouriensis* Banks of the South and West. The epigynum and palpal organs of these three species are so much alike that they cannot be used to distinguish them. In *nidifex* the black color of the under side of the first leg does not extend inward beyond the patella, and the coxæ are all light-colored, while in *Pikei* the whole of the first leg, including the coxa, is black, and in some individuals the whole of the second leg. In *nidifex* the whole upper surface of the body is a nearly uniform gray color with indistinct stripes on the abdomen, while in *Pikei* the color of both upper and under sides is darkest at the head, and gradually lighter backward with a distinct pattern on the abdomen. In *nidifex* the pads on the *tibia* and *metatarsus* are composed of shorter hairs, so that these legs look but two thirds as thick as they do in *Pikei*.

L. nidifex usually makes a turret at the opening of its burrow, sometimes only a slight ring, but often a tube of sticks or grass rising more than its diameter above the surface of the ground. Like *Pikei* the spider sits at the mouth of its burrow with the feet turned under and the head high enough to see the surrounding country. The burrows are often not more than eight or ten inches deep, sometimes curved to avoid stones. The turrets are most conspicuous in October and November, after the surrounding grass has withered. The burrows remain open all winter, the immature spiders lying partly torpid at the bottom. Freshly matured males and females are found in May.

Lycosa punctulata, Hentz. (Plate VII, figures 4, 4a.)

The legs of both sexes are shorter than in *scutulata.* In the male the first and second legs are not as much elongated as in *scutulata,* and the first legs are not darker than the others. The stripe on the abdomen is straight in both sexes, without light spots along the edges as in *scutulata.* The under side of the abdomen has irregular black spots which are wanting in *scutulata.* The palpal organs are shaped much as in *scutulata,* but the tarsi and all the joints of the palpi are a little shorter and stouter than in that species.

Framingham, Mass., Sept. 29, 1906.

Lycosa relucens, Montgomery. Proc. Phil. Acad. Nat. Sci., 1902. (Plate VI, figures 1, 1a, 1b.)

This species matures early in the season and is common around Boston in April in open woods. Its general color is that of dried leaves, and it resembles small individuals of *L. frondicola.* The length is 8 mm., the cephalothorax 4 mm. or a little less. The cephalothorax has a straight white middle stripe, the width of the middle eyes extending from them backward and slightly narrowed behind. There is a narrower white stripe near the edge each side, sometimes broken and indistinct in females, and straighter and more distinct in males. The legs are pale yellowish brown, with the femora faintly marked with gray rings that are sometimes absent, especially in males. The abdomen is indistinctly marked with pairs of gray spots and oblique lines. The epigynum has the common T-shape as wide as long, and a single arched opening in front, Fig. 1b. The male palpus has the tibia thickened so that it is nearly as wide as the tarsus. The tube of the palpal organ is abruptly curved forward, and a thin supporting appendage lies along the side of the tarsal cavity without extending beyond its edge. At the base of the tube is a large thick appendage extending forward, Fig. 1a.

New Haven, Conn., Mass., Lake Champlain, Vt.

Lycosa crassipalpis, new (Plate VI, figures 3, 3a.)

Three small males from Ipswich, Mass., and one from Portland, Me., are only 6 mm. long and the cephalothorax 3 mm. The male palpi have the tibia thickened as in *relucens,* but the tarsus and palpal organ are proportionally smaller and not wider than the tibia. The legs are pale without any gray rings on the femora. The lateral white lines on the cephalothorax are well defined and removed more than their width from the edge as they are in *biline-*

ata. The sternum has a light middle line for half its length, which shows indistinctly in the darker specimens.

Lycosa bilineata.

Pardosa bilineata, Em. N. E. Lycosidæ.

Lycosa ocreata, pulchra, Montgomery. Proc. Phil. Acad. Nat. Sci., 1902. (Plate VI, figures 4, 4a, 4b.)

The female of this species was described in N. E. Lycosidæ, from New Haven, Conn., without the male being known. This was later found at Cold Spring Harbor on Long Island. The female resembles in color and markings *Pardosa pallida* more than it does its nearest relative, *Lycosa ocreata.* It is 6 mm. long, with the cephalothorax 3.5 mm. The colors are light yellow and brown, with gray hairs on the legs and abdomen. The cephalothorax has three pale stripes, the middle one as wide as second row of eyes, the lateral half as wide and a little above the edge. The legs are pale yellow without any markings except faint traces of rings on the femora. The markings on the abdomen are like those of *ocreata*: a dark pointed stripe in the middle bordered by light stripes, outside of which are rows of dark spots. The colors of the male are the same except the tibia and end of the metatarsus of the first leg, which are deep black and surrounded by stiff black hairs, Fig. 4a. The epigynum is much like that of *relucens*, T-shaped, and as wide as long. The male palpi have the tibia slightly enlarged, but not as much as in *relucens* or *ocreata.* The palpal organ is like that of *relucens*, with the appendage supporting the end of the tube longer, so that it projects out over the edge of the tarsus, and the large thick terminal appendage is wanting.

Pardosa littoralis, Banks. (Plate VI, figures 5, 5a, 5b.)

This species described by Banks from Long Island, N. Y., where it is common, has now been found at Ipswich and Plum Island, Mass. The females are 7 mm. long, with the cephalothorax 3 mm. It is not as slender as *pallida* and *nigropalpis*, but has the proportions of *glacialis*, the young of which it much resembles, Fig. 5.

The color is pale yellow with gray markings. The legs are yellow without markings. The cephalothorax has a narrow black line each side and two wide dark stripes leaving a light stripe on each side and a less defined one in the middle. The abdomen has a middle light stripe with indented edges, and the sides are marked with light mixed with gray. In the male all the dark markings are darker than in the female.

The epigynum resembles that of *nigropalpis* but is shorter and stouter, Fig. 5b.

The male palpus also resembles that of *nigropalpis*, Fig. 5a, which I have figured from a Long Island specimen belonging to Mr. Banks.

Pardosa diffusa, new. (Plate VI, figures 6, 6a, 6b.)

Two males from Ipswich and Hyde Park, Mass. are distinguished from the ordinary male *nigropalpis*, even when running on the ground, by the darker color of the cephalothorax. The middle light band is narrow, and hardly shows in front of the dorsal groove. The light bands at the sides are very narrow and close to the edge. The legs are marked on the femora with broken rings darker and closer together from behind forward, the first femora being almost black. In the palpal organs the basal process is shorter and does not have the long curved hook which crosses the tube in *nigropalpis*, Fig. 6a. No mature females have been found in company with this, but females found in August without males in Massachusetts and Maine are supposed to belong to the same species.

The epigynum differs plainly from that of *nigropalpis* and *albopatella*. The anterior pit is rounder and wider, and the transverse posterior end is much wider than in the other species. The females differ in markings from *nigropalpis* and *albopatella* in the same way as the males.

Males from Ipswich, Hyde Park, and Sharon, Mass.

Females from Medford, Mass., Northern Maine, and Long Island, N. Y.

Pirata insularis, Em. N. E. Lycosidae (Plate VI, fig. 7).

A new figure is given of the markings of this species from a specimen from Danvers, Mass.

Pirata arenicola, new. (Plate VI, figures 9 to 9c.)

Female 6 mm. and male 4 mm. long. In the female the lateral light stripes are wide and extend over the edge of the cephalothorax, but in the male the edge of the cephalothorax is marked with a broken dark band. The legs are pale and faintly ringed with gray. On the under side the female is entirely pale, and the male has three gray lines on the abdomen.

The epigynum has two oblique lobes behind slightly pointed on the inner ends.

The male palpi have the tarsi shorter than in *P. sylvestris* more as in *piraticus*. The appendages of the palpal organ are all small,

the terminal process as usual divided into two branches, the outer straight and opaque, the inner thin and transparent and turned across the tarsus.

Ipswich, Mass., June 6, 1903.

Pirata maculatus, new. (Plate VI, figures 10, 10a, 10b.)

6 mm. long, the same size and much like *P. montanus.* The markings are the same as in *montanus,* but the dark portions are much darker, and the rings on the legs more distinct than in any other species. The dark markings of the under side are also more prominent than usual; there is a distinct light middle stripe on the sternum, and a light area in the middle of the abdomen, bordered at the sides with black and partly divided by a middle dark stripe, narrow in front and widened behind. The hinder part of the epigynum is divided into two lobes, slightly pointed in the middle, and showing no opening on the outer side.

Moosehead Lake, Me., Aug. 7. Females with eggs.

Pirata sylvestris, new. (Plate VI, figures 8 to 8c.)

Female 8 mm. long; male 5 mm. long. In the female the usual three light marks behind the eyes are very narrow, but the light marks at the sides are wide and extend to the edge of the cephalothorax. In the male the edges of the cephalothorax are dark and the lateral light markings narrow. The abdomen has the usual gray color with a light middle stripe in the anterior half, and four pairs of bright white spots covered with white hairs and indistinct white lines on the sides and along the sides of the middle stripe. The sternum is pale without stripes. The under side of the abdomen is in some individuals pale, while in others there are traces of three dark stripes. The legs are pale without rings. The epigynum has the usual two lobes behind bluntly pointed on the inner corners where they are partly covered by a middle bunch of fine white hairs. In some light colored females the spermathecæ show through the skin near the outer corners of the lobes.

The tarsus of the male palpus is slender. The palpal organ has the usual two small appendages in the middle, one slender and the other a short and stout tooth. The terminal process is long and curved in quarter of a circle, with the transparent inner branch showing beyond the outer which is thicker and darker.

Dolomedes sexpunctatus, Hentz. (Plate VII, figures 6, 6a, 6b.)

A male from Wellesley, Mass. has the cephalothorax 5 mm. long and the same in width. The hind leg 23 mm. The spider had been put in alcohol very soon after moulting and the legs and palpi are probably not fully extended. The markings are like those of the female and the colors like a young and pale female preserved in the same way.

The male palpus has a long process on the outside of the tibia nearly as long as the joint itself. It is thin and flat, widened and rounded at the end, and has a small tooth on the under side near the base. The end of the tibia is shrunken and should no doubt be wider at the end than at the base, as it is in a Tennessee specimen apparently of the same species. The palpal organ is like that of *D. fontanus.*

A nest of this species was found at Amherst, Mass., Sept. 5, 1905 on golden rod two feet above the ground. The nest was about three inches in diameter, and the young spiders, early in the morning, were gathered in the lower part of it. The female was on the plants a short distance below the nest.

Dolomedes fontanus, Em. New Eng. Lycosidæ.

The male of this species was described and figured in New England Lycosidæ in 1885. The female was described in the same paper under the name of *D. tenebrosus.*

Marx in a note in his catalogue of N. American Spiders in 1890 gave his opinion that these were male and female of the same species, which a study of more specimens has shown to be correct.

The female has the cephalothorax 9 mm. long and 8 mm. wide, and the abdomen varies from 10 mm. to 15 mm. The eyes of the front row are small and the middle pair only slightly larger than the lateral, while in *idoneus* the middle pair are twice as large. The epigynum, which is correctly figured in N. E. Lycosidæ, has a narrow middle lobe bluntly pointed behind. The color in alcohol inclines to be olive, while in *idoneus* it is reddish brown. The marginal white stripes on the cephalothorax in life connect together in front of the head. The light middle stripe, which is distinct on the cephalothorax of *fontanus,* is less so in *idoneus.* The sternum of *fontanus* has a distinct light middle stripe which is absent or very indistinct in *idoneus.*

The male is smaller than the female, with the legs more slender but as long as those of the female. The cephalothorax is as wide as long, measuring 7 mm. The first and fourth legs are of the same

length, 36 mm. The palpi are 9 mm. long with the tibia straight and with a forked process in the middle of the outer side. The tarsus and palpal organ have been correctly figured in N. E. Lycosidæ.

This species seems to be common as far south as the mountains of North Carolina. On Lake Champlain, Vt, and Lake Winnipesaukee, N. H., it matures about July 1, when it is common along the shore under loose stones and the floats of boat landings. It runs on the surface of the water and on the bottom, carrying a large amount of air adhering to its hairs. It remains under only a short time, coming quickly to the shore as soon as it has escaped pursuit.

Dolomedes idoneus, Montgomery. Proc. Phila. Acad. Nat. Sci., Nov. 1902. (Plate VII, figure 8.)

The female of this species is of the same size as *fontanus* and has similar markings, but the color in alcohol is reddish brown instead of olive gray, which is usual in *fontanus*. The shape of the head is the same as in *fontanus*, and the arrangement of the eyes is the same, the only difference being in the size of the front middle eyes, which in this species are twice as large as the laterals of the same row. The shape of the epigynum is characteristic of this species, even when half grown. The middle lobe is round and swells out beyond the surface of the abdomen, and there is a distinct opening on each side between it and the lateral lobes.

The male has not been described.

Females have been found at Lake Champlain, Vt., and at Simsbury and New Haven, Conn.

Dolomedes urinator, Hentz. Montgomery, Proc. Acad. Nat. Sci., Philadelphia, 1904.

The male spider described by me in 1885 as the male of *D. tenebrosus* appears to be *urinator* or *lanceolatus,* Hentz. I have not found females but have one from Pennsylvania sent me by Mr. Montgomery.

An immature male from Milton, Mass., resembles closely the drawing of *D. lanceolatus* by Hentz. It has the tuft of stiff hairs on the femur of the fourth leg, like the mature males that I have described.

Dolomedes vernalis, new. (Plate VII, figures 7 to 7d.)

Males from Falmouth, Me., and Three Mile Island, Lake Winnipesaukee, N. H. Cephalothorax 3 to 4 mm. in length and a little less in width. Fourth and first legs 16 to 18 mm. The colors are

pale yellow and gray. The cephalothorax is dark in the middle and light at the sides, with light gray spots over the coxæ. The dark middle area extends forward between the eyes to the front edge of the head, dividing into two below the eyes. The mandibles are striped on the front with black. The abdomen is light at the sides, and the middle dark marks are united into a broad stripe with irregularly indented edges. The legs are marked with broken dark rings, the femur and the tibia having parts of four rings each. The sternum is dark around the edges, and the whole under side of the abdomen is gray, darkest at the sides, with two indistinct light lines converging toward the spinnerets. The tibia of the male palpus is as short as the patella. The process of the tibia is as long as the diameter of the joint. It is flat and widened at the end, hollowed in at the middle, and with the corners sharp, and sometimes two little teeth in the hollow. The palpal organ resembles that of the other species.

A female just moulted, from Three Mile Island, Lake Winnipesaukee, N. H., May 25, 1905. Cephalothorax 6.5 mm. and abdomen the same length; fourth and first legs 24 mm. Colors and markings like those of male. The epigynum resembles that of *D. idoneus* with the middle portion not as prominent, and the pockets at the sides more open.

At Three Mile Island, between May 20 and 27, 1905, one female and several males made their last moult. They were under stones and loose boards lying on the ground near the shore.

Oxyopes scalaris (Hentz) Em.

This species was found again at Durham, N. H., in June 1904. It resembles closely a species found commonly on the Pacific Coast from British Columbia to California.

Œcobius parietalis.

Thalamia parietalis, Hentz. Journal Boston Soc. Nat. Hist. (Plate VIII, figures 1 to 1e.)

2.5 mm. long, pale and translucent, with black spots on the head and legs and around the sides of cephalothorax and abdomen. The cephalothorax is as wide as long, and almost circular. The eyes are on the top of the head in two nearly straight rows, the front row shorter than the upper, and the front middle eyes farther apart than they are from the lateral eyes. The upper middle eyes are not round but irregularly oval, largest from front to back. The head extends forward a little beyond the eyes, and under this

projection are the mandibles which are very small. The maxillæ are inclined toward each other, over the short and rounded labium. The sternum is as wide as long. The abdomen is oval, as wide as the cephalothorax, and one-half longer. It is marked with irregular opaque white spots, a black line around the front end and several pairs of black spots, Fig 1. The shape of the end of the abdomen and the arrangement of the spinnerest are very peculiar in this genus. At the end of the abdomen behind the anus is an oval appendage surrounded by a single row of curved hairs of the same thickness throughout their length, and rounded at the end. The hinder pair of the spinnerets are their length apart, and extend backward so as to be seen for nearly their whole length from above. The spinning tubes extend along the under side. The cribellum is slightly divided by a notch in the middle. The calamistrum consists of two parallel rows of ten or twelve sligthly curved hairs, extending half the length of the fourth metatarsus. The legs are all about the same length, and the feet have three claws. The epigynum has a double tube directed backward and resting in a shallow groove on the under side of the abdomen. The male has the legs longer and the abdomen smaller, but otherwise resembles the female. The male palpus has very short patella and tibia, and the tarsus is wide and oval, and the palpal organ thick and furnished with a cluster of short appendages near the base.

This *Œcobius* lives in houses and on walls and fences. It makes a flat web one to two inches long and half as wide, fastened at several points around the edges, leaving open spaces through which the spider can run in and out. The spider stands on the wall behind and not on the web.

It has been known since the time of Hentz in the Southern States, but has lately been found in a house in Roxbury, a suburb of Boston, where it seems to be well established around window frames and behind furniture.

Scotolathys pallidus (Marx) Simon.

Neophanes pallidus, Marx. Proc. Ent. Soc. Wash., 1891. (Plate VIII, figures 2 to 2 d.)

1.5 mm. to 2 mm. long and pale and translucent without any markings. The cephalothorax is shaped like that of *amaurobius.* The abdomen is slightly larger and wider than the cephalothorax and a little wider behind than in front. The eyes are six in number, large for the size of the spider, all about the same size and arranged in two groups. The cribellum is small, about as wide as one of

the anterior spinnerets. The calamistrum consists of seven or eight pairs of hairs about the diameter of the leg in length, Fig. 2c. The coxæ of the fourth legs are more than their diameter apart, and the end of the sternum extends backward beyond them in a blunt point, Fig. 2d. The epigynum shows externally two round spermathecæ, each crossed by an opaque spot, and in some specimens spiral tubes can he seen connecting with them. The male palpi resemble those of *Dictyna.* The tube of the palpal organ coils around the edge of the tarsus, where it is supported by a wide thin appendage; it curves around the base of the tarsus to the upper end, where it is twisted and rests against a blunt process of the tibia.

These little spiders live under leaves and are found by sifting in company with various Erigoneæ. They have been fond in various places around New Haven Connecticut and at Three mile Island, Lake Winnipesaukee, and Fitzwilliam, N. H.

Amaurobius borealis, new. (Plate VIII, figures 3 to 3d.)

Female 5 mm. and male 4 mm. long. The cephalothorax and legs are yellow brown, the legs darker toward the tips and the cephalothorax darker around the edges, but little toward the head. The abdomen is reddish brown with an indistinct pattern. The cribellum is small, not wider than the length of the first spinnerets and is indistinctly divided in the middle. It is on a slight elevation just back of the spiracle. The calamistrum occupies half the length of the metatarsus. The epigynum has a wide middle lobe, covered at the ends by the lateral lobes. The male palpus has the patella as wide as long, with one stout spine projecting over the tibia. The tibia is curved and has the usual complications shown in the figures.

Fitzwilliam, N. H., abundant near the Rhododendrons. Portland, Me., under leaves on the ground. Mature in May; females with eggs in July.

Orchestina saltitans, Banks. Ent. News, 1894, p. 300. (Plate I, figures 4, 4a, 4b.)

Cellar of Boston Soc. Nat. Hist. building, March 6, 1889. Found by Banks in house at Sea Cliff, Long Island, N. Y.

Micaria laticeps, new. (Plate X, figures 4 to 4c.)

One male of this species was found under a stone at New Haven, Conn. The length is 3 mm. The cephalothorax is a little higher than in the other species, and the head nearly as wide as the widest part of the thorax. The eyes of the upper row are at equal dis-

tances apart, and the whole group of eyes wide in proportion to the width of the head. The abdomen is oval and slightly indented in the middle. The colors are all dark, and were not noticed when the specimen was fresh. The cephalothorax is of the usual brown, and the legs the same color with the ends of the first and second pairs lighter. The abdomen seems to have been lighter in front of the depression, but there are no distinct markings to be seen in its present condition. The male palpi have no process on the tibia. The palpal organ is prominent as in *quinquenotata.*

Micaria quinquenotata, new. (Plate X, figures 1 to 1e.)

This species lives in sandy places, sometimes in company with *longipes*, which it resembles in color and habits. It is smaller than *longipes*, measuring 4 mm. in length, the cephalothorax between 1½ and 2 mm. in length. The cephalothorax is shorter and the head narrower than in *longipes* and the lateral eyes are nearer the middle pairs, Fig. 1a. The sternum and the legs are slightly shorter than in *longipes.*

The legs and cephalothorax are light orange brown, with scattered shining hairs of the same color. The abdomen is covered with iridescent scales, yellow in front, and darker toward the hinder end. The colors vary in different individuals and some are greenish gray as in *longipes.* There are two pairs of white spots on the abdomen, one pair in the middle and another at the front end, and just behind the front pair is a middle white spot of about the same size, Fig. 1.

The epigynum differs little from that of *longipes*, but is usually less regular in shape. The male palpi also are like those of *longipes* with a similar process on the tibia, Fig. 1a.

This species is common on the sand dunes at Ipswich, Mass., among the roots of sand grass. It matures about the first of June, when both sexes are active, running about on the sand from one bunch of grass to another, or hiding under any loose object lying on the ground. The cocoons which are found early in June are white and thin, and contain about eight eggs.

In pairing the male holds the female by the first and second legs around the thorax between her third and fourth, reaches his head under her and inserts the palpus of the same side as the clasping legs, Fig. 1.

Micaria gentilis, Banks. Canadian Entomologist, 1896. (Plate X, figures 3 to 3d.)

Mature males and females have been found from the middle of May to the first of July at Portland, Me., and at Monhegan, Me.

The cephalothorax is shaped as in *quinquenotata*, a little narrowed in front and not much elongated. In some individuals the cephalothorax is unusually narrowed behind, so that the widest part is in front of the middle. The cephalothorax is a little less than 2 mm. long. The abdomen is oval without any constriction in the middle, sometimes in females twice as long as it is wide, in males not much longer than the cephalothorax.

The color of the cephalothorax varies from light brown to black, covered with light shining hairs not very close together. The first and second legs have the femora dark like the cephalothorax, and the other joints light yellow. The third and fourth legs are brown, the femora darker. The sternum is dark brown and the front coxæ are the same color; the other coxæ are partly light colored; the fourth pair almost entirely light yellow. The abdomen is covered with dark green iridescent scales, with a narrow white band across tho middle, and in some individuals another transverse white band near the front end, but this is oftener broken into two short white streaks at the side.

The epigynum has a large opening in front, covered by a wide rim with a dark colored edge, Fig. 3d.

The male palpi have no process on the tibia. The palpal organ is flatter than it is in *longipes* and *quinquenotata*, but has a hook in the middle as in those species.

Castaneira lineata, new. (Plate X, figures 5, 5a, 5b.)

This small species has the general appearance of a *Micaria*. It measures 6 mm. in length, the cephalothorax nearly 3 mm. The cephalothorax is twice as long as wide, widest in the middle and narrower behind than in front. It is slightly indented at the sides between the second and third, and between the third and fourth legs, Fig. 5. The head is three-fourths as wide as the thorax, wider than in the other species, and the eyes are farther apart. The upper eyes are equidistant and cover three-fifths of the width of the head. The sternum is narrowed and pointed behind, more than it is in the other species. The abdomen is a little longer than the cephalothorax, widest behind and a little constricted in the middle. The pedicel is as long as wide and can be seen from above between cephalothorax and abdomen.

The color of the cephalothorax is dull orange as in *Micaria longipes*. The femora are marked with two longitudinal dark stripes as in *M. longipes* and *C. bivittata*. The other joints of the legs are orange

yellow, except the ends of the fourth legs, which are somewhat darker.

The abdomen is lighter in front and has two white spots at the sides, nearly meeting in the middle.

The epigynum resembles that of *C. pinnata* with two small holes wide apart.

One female from low bushes in Sharon, Mass., July 7, 1902.

Prosthesima rufula, Banks. Phil. Acad. 1892. (Plate IX, figures 6 to 6h.)

7 to 8 mm. long; cephalothorax 3 mm. A little smaller than *P. atra* and more slender. The cephalothorax is narrower across the middle and less pointed in front, and the legs are more slender and the front pair less distinctly larger than the others. The sternum is narrower than in *P. atra.*

The color is light reddish brown without markings, the abdomen paler than the rest.

The epigynum varies in shape, the edge in front varying from nearly straight to the shapes shown in the figures.

The male palpus has a process on the outer side of the tibia, that lies along the edge of the tarsus for about a third its length and is slightly twisted at the tip. The tube of the palpal organ is on the outer side and extends nearly straight the whole length of the tarsus.

New Haven, Conn., and Cold Spring Harbor, L. I. N. Y.

Pœcilochroa montana, Em. N. E. Drassidæ, etc., Trans. Conn. Acad. 1890. (Plate IX, figures 4, 4a, 4b.)

The female of this species was described in 1890 from the White Mountains, but only lately the male has been found on the Blue Hills near Boston. The individual is probably a small one and measures only 5 mm. in length. The cephalothorax is shorter and rounder than in *variegata,* and the legs proportionally a little longer. The difference in shape of the cephalothorax in these two species is shown in the sternum, which in *montana* is distinctly wider than in *variegata,* Fig. 4a. The color is less brilliant than in *variegata,* the orange of the latter species being absent. The cephalothorax is dark brown, covered with white hairs. The femora and basal joints of all the legs are dark brown or black and the other joints light yellow. The abdomen is black with a narrow white band across the middle, a wider white band across the front end, with a little black showing in front of it, and a white band at the hinder

end over the spinnerets. The male palpi resemble those of *variegata,* but have the process of the tarsus a little stouter and more curved at the tip.

Gnaphosa parvula, Banks. Proc. Am. Ent. Soc., 1896. (Plate IX, figures 3, 3a, 3b.)

This species is a little smaller than *brumalis,* the largest female measuring 8 mm. long, and the cephalothorax 3.5 mm. The color is the same rusty black as in the other two species. The lateral eyes of the upper row are placed as in *brumalis,* not as far from the middle eyes as in *conspersa.* The epigynum resembles that of *conspersa* more than *brumalis,* Fig. 3. The male palpi have the process of the tibia half as long as the tarsus, with the tip sharply pointed and a little curved, Fig. 3a. The palpal organ resembles that of *brumalis,* but the tube does not have a tooth at its base as in *brumalis,* Fig. 3b.

Ipswich, Mass. mature male and females, May 20. Described by Banks from Hanover, N. H.

Drassus hiemalis, new. (Plate IX, figures 1 to 1d.)

This species is a little smaller than *robustus.* The cephalothorax is 3 mm. long and a little narrower at the head than in *robustus,* and the lateral eyes are a trifle nearer together than in that species. The abdomen is a little more elongated than in *robustus,* and the epigynum farther back.

The epigynum is shaped somewhat as in *robustus,* but the lateral ridges are much thinner and lower, and in front of them is a transverse depression with a hard and dark colored rim, Fig. 1d. The colors are the same as in *robustus,* but lighter than most specimens of the latter species.

The males are the same size as the females. The male palpus has a process on the upper side of the tibia which is nearly straight, not curved as in *robustus,* and extends over the tarsus one-third its length. The palpal organ has several hard brown processes that cover the surface and nearly conceal the end of the tube.

From Blue Hill and from Hammonds Pond, Brookline, under leaves in winter. Three Mile Island, May 25, adult males and females.

Drassus bicornis, new. (Plate IX, figures 2, 2a, 2b.)

Slightly smaller than *D. hiemalis.* The cephalothorax 2.5 mm. long, but form and color are the same, and there is nothing to distinguish these two species except the epigynum and palpi. The

epigynum has a large oval opening divided at the posterior end into two. The hard brown part around the hole extends forward on each side like a pair of horns turning toward each other at the ends.

The male palpi have a long process on the upper side of the tibia that extends over the tarsus for a third of its length. It is narrowed in the middle and obliquely truncated at the end. The palpal organ is hard and brown, smooth around the base, and divided at the end into a complicated group of processes, Pl. IX, fig. 2a.

Three Mile Island, Lake Winnipesaukee, N. H.

Clubiona spiralis. (Plate X, figures 10, 10a, 10b, 10c.)

6 mm. long, fourth leg, 9 mm. Larger than *C. rubra* and longer legged, but resembling it in the short mandibles and the arrangement of the eyes with the upper middle pair farther apart than they are from the lateral eyes. The male palpi have a general resemblance to those of *rubra*, but the double lateral process is differently shaped, round at the base and with the tip sharp and curved upward. The tarsus and palpal organ are more elongated than in *rubra*, and the large black process more slender. The only specimen found is pale, even to the mandibles.

Magnolia, Mass.

Two females, one from Ipswich, Mass. and one from the Blue Hills appear to belong to this species. They are the same size and color and have the same eye arrangement, with the legs shorter and stouter, us usual in females of this genus. The epigynum is shown in Fig. 10c. It has a partly divided transverse opening turned forward.

Clubiona præmatura, new. (Plate X, figures 7, 7a, 7b.)

In N. E. Spiders of the Family Drassidæ, etc. this species is confounded with *C. ornata* (Americana Bks.), on account of the distinct dorsal markings of the female which until recently was the only sex known. It is a little smaller than *ornata*, the cephalothorax of the female being 2.2 mm. long, and the abdomen from 4 mm. when filled with eggs, to 3 mm. after the eggs have been laid. The color is pale, with the cephalothorax slightly darkened on the head and mandibles. The abdomen has a pattern similar to that of *ornata*, but less distinct. The arrangement of the eyes is similar to that of *ornata*, the upper middle pair being only slightly farther apart than they are from the lateral eyes. The shape of the border of

the epigynum is constant and characteristic. It does not extend backward in a point as in *ornata* and *rubra*, but is transverse with a deep notch in the middle, Fig. 7b.

The male has the cephalothorax narrower in front than the female, and the palpi short, with little resemblance to those of *ornata*. The tibia is widened into a large process on the outer side, without any sharp teeth. The tube of the palpal organ is short and turned backward, and the other appendages are short and blunt, Fig. 7.

This species is very abundant under stones all over the top of the Mt. Washington range. The females make thin silk nests and lay their eggs about the first of July, by which time the males are scarce.

Agrœca pratensis, Em. Trans. Conn. Acad., 1890.

Females with epigynum like *A. repens* Em. Trans. Conn. Acad., 1894, have been fond in several New England localities at the same time with males of *pratensis* which makes it probable that *pratensis* and *repens* are one species with two forms of epigynum.

Anyphæna rubra, Em. N. E. Drassidæ. Trans. Conn. Acad., 1890. (Plate IX, figures 8 to 8c.)

The males of this species as well as the adult females are rarely found, because they mature very early in the season. A young male that had wintered under leaves was taken in Franklin Park, Boston, April 17. and moulted April 22.

The males differ but little from the females in size and color, but as usual are a little more slender and have longer legs and longer and straighter mandibles. The male palpi have a long process on the outer side of the tarsus, curved outward and slightly notched at the end, and in some individuals sharply pointed. The palpal organ swells out from the tarsus at the base. The tube begins on the inner side and curves around the base of the palpal organ and along the outer side of the tarsus nearly to the tip, Fig. 8.

Apostenus acutus, new. (Plate IX, figures 7 to 7c.)

Immature males 4 mm. long. An adult male, which is dried and shrunken is of the same size. The cephalothorax is oval and much narrowed in front, so that the head is only one-third as wide as the widest part of the thorax. The eyes are low and arranged as in *Agrœca pratensis*, except that the front middle pair are much smaller. The front row is slightly curved upward, the middle eyes less than

half as large as the lateral. The upper row is more curved; the eyes all about equal in size, and the same distances apart. The lateral eyes of the two rows are near each other, but do not touch. The legs are long, with long spines, the fourth pair longest. The tibiæ of the first and second legs are thickened and have on the under side two pairs of long spines under the metatarsi. The sternum is almost circular with a slight point behind between the fourth coxæ.

The colors are translucent white and dark gray, like *Phrurolithus alarius*, but usually darker. The cephalothorax is light in the middle, with black edges and radiating dark lines. The abdomen is dark, with a series of pairs of light spots down the back. On the under side the sternum and coxæ are light and the abdomen spotted irregularly with dark gray. The male palpi in an individual that has been dried have the tibia and patella of about the same length. The tibia has a stout process on the outer side that turns inward against the base of the tarsus. The tarsus is oval, and the palpal organ long and thick. The tube seems to start near the outer end and curve around toward the inner side.

Adults were found at New Haven, Conn., May 1, and young males at Cold Spring Harbor, April 10.

Cœlotes calcaratus, Keys. Zool. bot. Ges. Wien, 1887.
Cœlotes longitarsus, Em. Trans. Conn. Acad., 1890.

On Plate VII, Vol. VIII, fig. 2a is not the epigynum of this species but that of *Cicurina arcuata*. A correct figure of the epigynum of *C. calcaratus* is given in Common Spiders of the U. S. by J. H. Emerton 1902, page 104, fig. 242.

Cicurina arcuata, pallida and **brevis.** (Plate VIII, figures 6 and 7e.)

The three species of *Cicurina* live under dead leaves on the ground at all seasons, all three being sometimes found in the same locality. *C. arcuata* Keys. = *complicata* Em. is the largest and most deeply colored, with the abdomen covered with gray oblique marks. *C. pallida* is of the same shape and a little smaller, without markings. It is less common than the other two. *C. brevis* = *Tegenaria brevis* Em. = *C. creber* Banks, is smaller than the others and pale, with two rows of gray spots on the abdomen. The cephalothorax of the male is rounder and the head narrower than in the female, and more so than in the males of other species. All the species have very complicated palpal organs and a large appendage of the tibia of the palpus which lies against the tarsus and is not easily

distinguished from parts of the palpal organ. In *P. arcuata* this appendage is as long as the palpal organ and nearly as wide. In *C. brevis* it is narrow but longer than the rest of the tibia. This appendage was not noticed in my description of *Teg. brevis* but is correctly described by Banks under *C. creber* in the Spiders of Ithica. In *C. pallida*, although it is larger than *brevis*, the palpal organ is smaller, and the appendage of the tibia reaches only to its base.

Cicurina arcuata, Keys. Zool. bot. ges. Wien, 1887.
Cicurina complicata, Em. Trans. Conn. Acad., 1890.
In New England Agalenidæ &c. Trans. Conn. Acad., 1890, Pl. VII, fig. 2a is the epigynum of this species, not of *Coelotes longitarsus.*

Cicurina pallida, Keys. Zool. Botan. Ges. Wien, 1887. (Plate VIII, figures 7 to 7c.)
5 mm. long and pale and without markings. The cephalothorax is 2.5 mm. in length and 1.5 mm. wide, the head only a little narrower in the male than in the female. The epigynum is smaller than that of *C. brevis* and the parts seen through the skin rounder. The tarsi of the male palpus are as long as those of *brevis*, but more pointed and the palpal organ is smaller and more simple, though resembling in its general structure that of *brevis.* The process of the tibia which is so long and conspicuous im *complicata* and in *brevis*, is in *pallida* but little longer than the rest of the tibia, Pl. VIII, fig. 7.
Found under leaves at Sharon and Northfield, Mass., in company with *brevis* and *complicata.*

Cryphoeca montana, new. (Plate VIII, figures 4 to 4i.)
Cryphoeca peckhamii, Simon, from Washington territory, resembles this species.
Males 4 mm. long, females 3 mm. General appearance like a small *Coelotes* or *Amaurobius.* The cephalothorax is narrowed in front of the first legs and at that point is as high as wide, curving downward toward the eyes. The eyes cover half the width of the front of the head, both rows arched upward. The upper row is largest, the eyes of equal size, and equal distances apart. In the lower row the middle eyes are half the size of the lateral. The lateral eyes of both rows touch each other. The sternum extends in a long blunt point between the coxæ of the fourth legs. The legs are of moderate length, the fourth longest in females, and the first in males. The first and second legs have two spines on the

outer side of the tibia, and four on the inner side, and three pairs of spines on the metatarsus. In females these spines are long, more than half the length of the tibia; in males they are short like the spines of the other legs. The abdomen is oval, not much longer than wide, resembling in shape as well as in markings that of *Amaurobius sylvestris*. The lower spinnerets are wide apart, and there is a wide opening to the tracheæ between and in front. The edge of the tracheal opening is thickened and colored on the inner side so that it resembles a small cribellum.

The colors are translucent white and gray. The legs are marked with broken dark rings at the ends and middle of the joints. The cephalothorax has a narrow black edge and broken radiating dark marks like *Cælotes medicinalis*. The abdomen is marked with a series of oblique light spots in pairs like *Amaurobius*. On the under side the abdomen is light in the middle; the coxæ are light, and the sternum is light in the middle and dark at the sides. The light color turns yellow by long keeping in alcohol.

The male palpi have two processes on the tibia—one on the upper side turned outward and sharp pointed, the other on the outer side about half as long, stout, and directed forward. The palpal organ is large, extending backward beyond the base of the tarsus. The tube begins at the hinder end, extends around the inner side and ends in the groove of a thick process on the outer side.

Adult males and females half-way up Mt. Washington, June 10. Females Stow, Vt., July 29, Miss Bryant. Young males under leaves Jackson, N. H., in February.

Hahnia brunnea, new. (Plate VIII, figure 5.)

A single female from Clarendon Hills maple swamp is 3 mm. long, three-fourths the size of *agilis*. The proportions of the body, the eye arrangement and the shape of the sternum and maxillæ are the same as in *agilis*. The opening of the trachea is midway between the epigynum and spinnerets, not as far forward as in *agilis*. The spinnerets are in a line, with the lateral pair slightly larger than the others as in *agilis*, but the spinnerets are closer together, the middle pair almost touching. The lateral spinnerets are shorter than in *agilis*, being a third the length of the abdomen, while in *agilis* they are half as long as the abdomen. The epigynum is shaped much as in *agilis*, but on each side there is a brown loop under the skin that does not show in *agilis*. The color is light brown, the legs without rings or markings. The cephalo-

thorax is light brown, a little lighter than the abdomen. The abdomen is marked by a middle row of five pairs of oblique light spots, and the front pair of muscular spots is not conspicuous as it is in *agilis*.

Hanover, N. H., C. M. Weed in N. Banks' collection.

Phidippus albomaculatus, Keys. Zool. bot. ges. Wien, 1885.

P. mystaceus, Em. Trans. Conn. Acad., 1891.

P. incertus, Pkm., 1901 from Texas is thought to be the *Attus mystaceus* of Hentz.

Phidippus brunneus, Em. Trans. Conn. Acad., 1891. (Plate XI, figure 1.)

Male a little smaller than the female, and the same general color. The cephalothorax is darker than in the female, and the abdomen covered on the upper side with dull yellow hairs. The legs are darker than those of the female. The mandibles are iridescent green. The male palpal organ is short and wide at the base, and the tube is stout and with a double bend: Pl. XI. fig. 1.

Found at the same time with females at Hyde Park. Mass., May 2, 1903.

Phidippus Whitmani. (Plate XI, figure 5 and Plate XII, figure 1.)

The male of this species is very distinctly marked. It is about 8 mm. in length, larger than most males of *multiformis*, Pl. XII, fig. 1. The cephalothorax and abdomen are red, in some individuals inclining to orange. There is a distinct black band across the front of the head behind the eyes and as wide as the largest eyes. There is a narrow yellow band around the front of the abdomen, and in some individuals two pairs of indistinct yellow spots near the hinder end, but in others the whole back of the abdomen is red without any spots. In alcohol the spots are more distinct, and another pair of spots often shows in front of the others. The legs and palpi are gray with irregular dark and light spots obscured by long hairs. In alcohol the femora are dark and the other joints have dark rings at the end. The palpal organ is long and narrow, the bulb extending backward the whole length of the tibia. Pl. XI, fig. 5. The writer does not know the female.

Sharon, Mass. Three Mile Island, N. H.

Phidippus insignarius, Koch. 1846. (Plate XI, fig. 2 and 2 d.)

The male is described by Peckham as the male of **Phidippus comatus** in Trans. Wisconsin Acad., April, 1901.

Male 8 mm. long; cephalothorax black with two wide white stripes beginning below the lateral eyes in front, and turning upward behind, where they nearly meet under the front of the abdomen. There are two pairs of tufts of long black hairs at the sides of the head. The abdomen is orange red with black and white markings; there is a white stripe around the front, and a scolloped black middle band including a middle orange spot, and two smaller orange spots in front of it. The ornamentation of the face and front legs is striking and complicated. The lateral white stripes extend around under the front eyes as far as the middle pair, but do not meet under them, and below these are long white hairs that cross each other and nearly cover the mandibles, so that their iridescent blue color is concealed. The palpi are white, with a little mixture of brown. The first legs are covered on the under side with long white hairs; the hairs of the coxæ point downward, nearly to the ground; the femur has a row of stiff white hairs as long as its diameter along the outer side, and the other joints have hairs extending more than their diameter each side to the ends of the tarsi. When the first legs are pointed upward, the whole front appears white except the upper part of the head, which is black, extending outward at the sides in four black tufts. When the first legs are down in walking position, the upper side becomes visible in front, and this is covered with black hairs at the sides and, as far back as the patella, with a middle stripe of orange. The second leg is striped in the same way, but not as brightly, and has shorter white hairs.

The female is a little larger than the male, and marked on the back less distinctly in the same way. The cephalothorax is brown with lateral white stripes and tufts of long hairs on the head as in the male. The abdomen is light and dark brown with gray hairs; there is a white stripe around the front end and a square white spot in the middle. The dark middle band is broken into two pairs of black spots in the front half. The epigynum has a small notch in the hinder edge and two anterior openings close together separated only by a narrow ridge.

Dendryphantes Jeffersoni, new. (Plate XI, figures 3 and 3 e.)

Males 4 mm. long. Color brown mixed with white and yellow. The cephalothorax has the usual white stripes at the sides that

connect in front with a large white patch extending backward in the middle nearly as far as the dorsal eyes. The abdomen is marked with a front white band and five or six pairs of white spots extending forward on their inner corners. The legs are ringed with white at the ends of the joints. In alcohol the white disappears and the abdomen appears marked with a series of black spots on a light ground. The first legs are 5.5 mm. long, with the tibia a little thickened. The palpus of the male differs but little from that of *capitatus* and *flavipedes*. The bulb is wide at the base and more nearly square than in *capitatus*. The tube resembles that of *flavipedes* in having a long process parallel to it, but both are curved in a half circle, fig. 3.

Two males were found in the moss near Spalding's Spring on the Mt. Washington range at a height of 5000 ft., July 6, 1904, and a female at the same place, July 4, 1907.

A female found in the same locality several years later is 7 mm. long and dark brown with light gray hairs without any distinct white or yellow marks. In alcohol the abdomen shows indistinctly light marks similar to those at *militaris*. The epigynum has the notch shallow and truncate and the two openings a little farther apart and more angular than in *militaris*.

Dendryphantes flavipedes, Pkm. Trans. Wisc. Acad., 1888. (Pl. XI, figures 4, 4 a.)

The males do not differ from the females as much as in *capitatus* and *militaris*. My specimens are 4 mm. in length. The cephalothorax is light brown as in female *capitatus*, with white longitudinal bands at the sides below the eyes widening behind. The abdomen has the dark middle area broken by three pairs of spots in the front half and three or four light chevrons behind. The dark area is less sharply defined than in the male *capitatus* and connects with several oblique rows of dark spots. The legs are not ringed as in the other species but pale and translucent with longitudinal dark lines on the inner side. One of the the males from Portland, Me., and others from Fitzwilliam, N. H., are light gray, almost as light as *Drassus saccatus* without any distinct markings on the back, but with fine distinct longitudinal black stripes on the legs. The male palpi are a little darker than the legs and the tarsi and the palpal organs resemble those of *D. capitatus*, except that the tip of the palpal organ is double, the tube having a slightly curved process longer than itself parallel with it on the outer side. The process

of the tibia is short and transverse, differing little from the same part in the other species.

Long Island, Portland, Me., Sept. and Crawford Notch, N. H., July 4. Fitzwilliam, N. H. in July.

Eris nervosus, Pkm. Wisconsin Academy, 1888.
Zygoballus terrestris, Emerton. N. E. Attidae, 1891.

Icius similis, Bks. 1895. Colorado.
I. elegans, dark variety, Em. Conn. Acad., 1891.

This species is described in New England Attidae as a variety of *Icius elegans.* The colors are not as brilliant, and it does not have the tufts on the front legs or such large tufts over the eyes. The palpal organs also differ slightly from those of *elegans* as figured in N. E. Attidae.

Icius formicarius, Em. New Eng. Attidae, Trans. Conn. Acad., 1891. (Plate XI, figures 8, 8 a.)

The male of this species has been found by Miss E. B. Bryant, July 3, 1904, at Allston, Mass., near Boston. It resembles the female in form and color, and has no tufts on the head and no peculiar modifications of the front legs. It is 4.5 mm. long. The male palpi resemble those of the other species of *Icius*; the patella and tibia are both very short, the tibia shorter than it is wide, and having a process on the outer side longer than the rest of the tibia. The palpal organ has the same general shape as in *elegans* and *Hartii*, but is a little more elongated, and the tube is a little more slender. In the same neighborhood with this male, a female 6 mm. long was found under a stone with a cocoon of eggs.

Mævia tibialis, Koch. 1848. XIV, p. 78.
Admestina Wheeleri, Pkm. Trans. Wisconsin Acad., 1888. (Plate XI, figures 6, 6 a.)

The female is 4 mm. long, the cephalothorax 1.5 mm. The cephalothorax is one-half longer than wide,—a little the widest across the hinder half and flat on the top. The abdomen is oval,—widest across the middle. The spinnerets are long, the third pair extending their whole length behind the abdomen. The legs are short, the first pair a little thickened, and as long as the cephalothorax. The sternum is one-half longer than wide and pointed at the posterior end; it is narrow in front, but does not extend beyond the first coxæ. The cephalothorax is covered with white hair but in alcohol

appears black. The abdomen is white with a middle gray band broken at the edges by spots and indentations. The legs are white with black spots at the ends of the joints.

The epigynum is large for so small a spider and is at the end of the first third of the abdomen. It has two large spermathecæ that show through the skin, and two small openings in front of them.

Hyctia Pikei, Pkm. Trans. Wisconsin Acad., 1888. (Plate XI, figures 7, 7 c.)

Cephalothorax and abdomen both elongated and narrow, whole length 6 to 8 mm., cephalothorax 2.5 to 3 mm. Abdomen 1.5 to 2 mm. wide; cephalothorax two-thirds as wide as long, a little wider in males than in females. The second, third and fourth legs are short and slender, but the first pair are thickened in both sexes, in the females twice as long as the cephalothorax, and in the males longer. The color is light gray with brown markings. In females the cephalothorax has three light brown longitudinal stripes, two extending the whole length from the lateral eyes and a middle stripe on the hinder half only. The abdomen has three fine stripes or rows of spots, sometimes forming a broken wide middle stripe. In males the whole middle of the abdomen has a wide brown middle band partly divided into triangular spots. Young individuals sometimes have no markings at all and are greenish in color like the sand grass in which they live. When approaching the female the male raises his front legs stiffly upward at an angle of sixty degrees with each other, and lifts the abdomen slightly, walking on the six short legs.

The sternum is half as wide as long and pointed at both ends, and the first and fourth coxæ are close together and may touch each other. The epigynum has a simple oval opening with a thickened edge in front. The male palpi are very short; the patella is as long as wide, and the tarsus is shorter, but with a thick pointed process on the outer side, as long as the rest of the tibia. The tarsus is curved downward and has a ridge along the outer side, the part below which is smooth, with few and short hairs. The bulb of the palpal organ projects at the base in a long blunt point.

Common on sand grass along the sea shore.

Pellenes viridipes, Hentz.

Pellenes Howardi, Pkm. Bull. Wisconsin Nat. Hist. Soc., Oct., 1900.

Attus viridipes, Hentz. Boston Journal Nat. Hist. 1846. (Plate XII, figures 5, 5 a.)

The male is 5 mm. long with the cephalothorax 3 mm. long. The colors are bright and the markings of the back sharply defined. The first legs are light, transparent green, and the other light portions pale fawn color. The green fades entirely in alcohol. The top of the head covering the whole area between the eyes is orange brown, and the dark markings are dark brown, almost black. The pattern can best be seen in the figures. The front legs have a narrow stripe of fawn color on the upper side dividing the green, the other legs and palpi are fawn color, broken along the sides by dark scales, forming parts of rings at the ends of the joints. The three inner spines of the front tibia are dark colored and flattened and two of them are long and spatulate, showing distinctly beyond the hairs. The patella of the third leg is widened and flattened and has a black and white eye spot and a black border under the eye spot, and just over the joint is a spine slightly turned up at the end. When the third legs are drawn up in the usual standing position, the modified patellæ show in front over the head. The face below the eyes is for a short distance dark brown and below this white. The mandibles are also white on the front.

The female is slightly larger than the male, but the cephalothorax smaller. The color is dull orange brown, at first sight uniform, but showing indistinctly the same light and dark pattern as the male.

The males mature about the first of May and the females a little later. The females are usually found under stones and the males moving about in dry paths in the woods in Hyde Park and Sharon, Mass. It has been found at several places across the country as far as California.

Pellenes roseus.

Attus roseus, Hentz. Journal Boston Soc. Nat. Hist. 1846. (Plate XII, figure 4.)

Male 4 mm. long, cephalothorax 2 mm. Neither the first or third legs are modified or ornamented. The cephalothorax and the front of the abdomen are bluish white and covered with fine short scales. The rest of the back of the abdomen is light pink, with a metallic lustre. The legs and palpi are thinly covered with white scales, and the color is modified by dark hairs and the yellow of the skin. The face and mandibles are covered with white scales, the mandibles indistinctly striped with black.

The female is the same size as the male and resembles the female of *splendens*. The cephalothorax is covered with light gray scales mixed with darker hairs. The abdomen is light fawn color and

black. There is a light band each side and one across the front of the abdomen. There is also a light middle band indented at the sides, extending forward from the spinnerets two-thirds the length of the abdomen. The legs are light gray without any markings. On the under side of the abdomen there are three dark lines.

Ipswich, May 20, 1893, in an open field near the shore. Specimens from New York State were found and sent to Mr. Peckham at about the same time.

Pellenes agilis, Banks. Ent. Soc. N. Y. 1892.

Pellenes auratus, Pkm. Bull. Wisc. Nat. Hist. Soc., Oct., 1900. (Plate XII, figures 3, 3 a, 3 b.)

5–6 mm. long, the cephalothorax 3 mm. long. The female is covered with bluish gray hairs, through which can be seen indistinct white markings on the abdomen and dark gray at the ends of the joints of the legs. In alcohol the light gray color disappears, and dingy gray and brown take its place on which the white and dark markings show more distinctly. The male is brightly marked with black and white. The cephalothorax has a pair of white stripes at the sides and another pair just above the lateral eyes extending its whole length, and a white middle stripe from the front middle eyes as far back as the posterior eyes. The abdomen has lateral and middle white stripes connected in front; the lateral stripes are broken in their hinder half into two white spots, and the middle stripe is sometimes broken into spots at the end. The second, third, and fourth legs are irregularly ringed with gray and white, but the first pair are highly ornamented with long black hairs and white spots, Pl. XII, fig. 3 a, 3 b. The first leg has the femur black with short hairs like the other legs, the patella white with a crest of white hairs above and long black hairs below, the tibia black with a white spot on the upper side near the end, and long black hairs above and below, the metatarsus and tarsus white. The third legs have no peculiar modifications of the patella or tibia. The palpi have the tarsus black and the patella white.

In marsh grass and under sticks and stones along the shore, Ipswich, Mass., Long Island, New York.

Males and females mature about August 1. In dancing before the female, the male holds the front legs out sidewise with the tibia nearly horizontal and the tarsus turned downward, and walking on the other six legs, approaches her by short quick steps without much movement from side to side until near enough to touch her and then quickly retreats.

Pellenes borealis, Banks. 1895.

Habrocestum cristatum, Pkm. Attidae of N. A., 1883. (Plate XII. figures 4 to 4 c.)

The female is 5—6 mm. long, the male 4.5—5 mm. The female is light gray and brown like the sand, while the male is deep black with white markings. The legs of the male have no peculiar modifications either of the first or third pairs. The markings of the female are very indistinct; the cephalothorax is varied with white, sometimes suggesting two white lines from the lateral eyes backward. The abdomen has a white line across the front and two pairs of short lines at the sides. Toward the end there are two middle spots, sometimes connected, and the usual two small white spots just in front of the spinnerets. The male has the cephalothorax black with long black hairs on the front of the head. The abdomen is black and has the same markings as the female, but much whiter and more distinct. The legs are pale, but the color is darkened by black hairs. The face below the eyes is white in the female, and in the adult male is thinly covered with small white scales, but in the young male before the last moult, this part is bright red, so that it may be mistaken for the young of *P. cæcatus*, which lives farther south. See Psyche, Journal of Cambridge Ent. Club, Vol. II, p. 32, April, 1904.

The epigynum has a large oval anterior opening extending backward at the sides almost as far as the posterior opening. The palpal organ is oval and has a stout supporter of the tube extending along the inner side and but little narrowed toward the end.

This spider is very common along sea beaches in the dry grass and rubbish thrown up by the tide. Adults are found most abundantly about the first of May, but some of them mature in the late summer as early as the last of August. The red-faced young males are found in the summer and fall, and in spring as late as June.

Chalcoscirtus montanus.

Icius montanus, Banks. Can. Ent., 1896.

The cephalothorax is 1.2 mm. long, the abdomen of the male about the same length, and that of the female longer. The cephalothorax is two-thirds as wide as long, a little flattened above and with the sides nearly straight and parallel. The posterior eyes are half as far from the front eyes as they are from each other and the middle eyes are slightly nearer the posterior than the front eyes. The color differs in the sexes, the male being much darker than

the female. The male is dark brown, almost black, without any markings, and the abdomen is slightly iridescent. The female has the cephalothorax dark brown and the abdomen light brown with pale herringbone markings like the female *Euophrys*. The legs of the female are pale. The fourth leg is longest in both sexes. The male palpi are short with the patella and tibia of equal length, the patella thicker than the tibia. The tarsus is oval and does not cover the bulb, which is thick at the base and extends backward under the tibia nearly its whole length. At the distal end of the bulb a small oval piece is constricted off and turned to one side, and at the tip of it is the small sharp tube. The epigynum resembles that of *Neon* and *Euophrys*.

Sifted from moss on the upper part of Mt. Washington range. July 4, 1907.

Homalattus cyaneus, Pkm. N. A. Spiders, Trans. Wisconsin Acad. Oct., 1888

Attus cyaneus, Hentz. (Plate XI, figure 9, 9a.)

Female 4 mm. long and 1.5 mm. wide. The part of the cephalothorax showing in front of the abdomen is as wide as long, narrowed a little in front. The posterior eyes are very far back, two-thirds as far from the front of the head as they are from each other. The cephalothorax and abdomen are both flattened, and the front of the abdomen covers the cephalothorax about a quarter of its length. The color is metallic green, the cephalothorax roughened and covered with small scales nearly as wide as long, and the abdomen with small but longer scales.

New Haven, Conn. and Sharon, Mass. under shingle of a barn.

Peckhamia picata.

Synemosyna picata, Hentz. Journal Boston Soc. Nat. Hist. 1846. (Plate XII, figures 7, 7a, 9b.)

This species continues to be rarely found in New England. Adult males and females were found in May, 1906, at Three-Mile Island, Lake Winnipesaukee, N. H., and adult females in July at the same place. They lived on a dry hillside among dead leaves on the ground and were seen walking slowly in and out among the leaves, resembling ants of the same size and color that were wandering over the same neighborhood. The male figured was 4 mm. long. The dancing of the male of this species before the female has been described by Peckham in the Occasional Papers of the Nat. Hist. Soc. of Milwaukee, Vol. 2, 1892.

Peckhamia scorpionia.

Synemosyna scorpionia, Hentz. Boston Journal Nat Hist. 1846. (Plate XII, figures 6, 6 a.)

This little spider was found at New Haven, Conn., in 1883 but was overlooked at the time of publication of the N. E. Attidae. Since then it has been found in considerable numbers at Cold Spring Harbor, Long Island, N. Y., and at Cambridge and Ipswich, Mass., always on fences on which it runs about slowly and irregularly like an ant. When threatened it flattens itself against the wood, holding on so tightly that it is hard to pick it up without injury. The males mature about June 1 and when confined with females dance before them much like *picata*, holding the abdomen up vertically and swinging it toward the advancing side and sometimes turning the feet of that side under the body. The front legs are not turned forward as much as in *picata*.

The females are about 3 mm. long, the males 2 to 2.5 mm. The cephalothorax is twice as long as wide, and widest across the hinder third. The posterior eyes are farther back than the middle of the cephalothorax. The abdomen is oval, slightly widest behind, and both it and the cephalothorax are flattened on the upper side and without any constrictions or indentation.

The legs are short and slender and the first pair thickened in both sexes. The color is dull brown and gray with pale markings. On the cephalothorax there is a transverse light spot just behind the eyes. On the abdomen there are two white stripes across the middle and between them two light spots connected with the anterior band. The space between the light bands is slightly paler than the rest of the abdomen. The legs are pale with a dark longitudinal stripe on the front side. The femora are darkened a little in the first, and less in the second and fourth pairs. In the male the first legs have the tibia and patella thickened as well as the femur, but not flattened on the upper side as they are in *picata*.

Myrmarachne albocinctus, Koch.

Salticus albocinctus, Koch. 1846. Vol. XIII p. 36.

Salticus ephippiatus, Em. Trans. Conn. Acad. 1891,

It is doubtful if this is the **Synemosyna ephippiata** of Hentz neither his description nor figure show the thickened palpi.

INDEX

page

Acrosoma rugosa . . . 173
Admestina wheeleri . . 227
Agroeca pratensis . . . 220
Agroeca repens . . . 220
Ancyllorhanis 175
Amaurobius borealis . . 214
Anyphæna rubra . . . 220
Apostenus acutus . . . 220
Argyrodes cancellatus . . 184
Argyrodes larvatus . . 184
Attus cyaneus 232
Attus roseus 229
Attus viridipes . . . 228

Bathyphantes calcaratus . 197

Caseola alticeps . . . 187
Caseola herbicola . . . 186
Castaneira lineata . . . 216
Ceratinella formosa . . 185
Ceratinopsis alternatus . . 185
Ceratinopsis auriculatus . . 185
Chalcoscirtus montanus . . 231
Cicurina arcuata . . 221, 222
Cicurina brevis . . . 221
Cicurina complicata . . 222
Cicurina pallida . . 221, 222
Clubiona præmatura . . 219
Clubiona spiralis . . . 219
Cœlotes calcaratus . . . 221
Cœlotes longitarsus . . 221
Cryphoeca montana . . 222
Cryphoeca peckhamii . 177, 222

Dendryphantes flavipedes . 226
Dendryphantes jeffersoni . 225
Described species 1882–1892 . 179
Dicyphus trilobatus . . 191
Dismodicus alpinus . . 190
Dolomedes fontanus . . 210

page

Dolomedes idoneus . . . 211
Dolomedes sexpunctatus . 210
Dolomedes tenebrosus . . 210
Dolomedes urinator . . 211
Dolomedes vernalis . . 211
Drassus bicornis . . . 218
Drassus hiemalis . . . 218

Ecobius parietalis . . . 212
Enoplognatha rugosa . . 182
Epeira angulata . . . 198
Epeira corticaria . . . 199
Epeira juniperi . . . 200
Epeira labyrinthea . . . 200
Epeira nigra 198
Epeira nordmanni . . . 199
Epeira silvatica . . . 198
Epeira solitaria . . . 198
Epeira thaddeus . . . 200
Epeira verrucosa . . . 173
Erigone brevidentatus . . 194
Erigonoplus gigas . . . 187
Eris nervosus 227
Eucharia atrica . . . 201
Exechophysis palustris . . 188

Grammonota gigas . . . 187
Gnaphosa parvula . . . 218

Habrocestum cristatum . . 231
Hahnia brunnea . . . 223
Histagonia palustris . . 188
Homolattus cyaneus . . 232
Hyctia pikei 228
Hypselistes 176

Icius elegans 227
Icius formicarius . . . 227
Icius montanus . . . 231
Icius similis 227

page

Lasaeola cancellata . . 184
Latrodectus mactans . . 181
Linyphia conferta . . 174, 195
Linyphia maculata . . . 195
Lophocarenum abruptum . 189
Lophocarenum alpinum . . 190
Lophocarenum cuneatum . 188
Lophocarenum quadricristatum 189
Lophocarenum minutum . 191
Lophocarenum rugosum . . 191
Lophocarenum trilobatum . 191
Lophomma 176
Lycosa arenicola . . . 204
Lycosa avara . . . 202
Lycosa baltimoriana . . 203
Lycosa bilineata . . . 207
Lycosa carolinensis . . 203
Lycosa crassipalpis . . 206
Lycosa frondicola . . . 203
Lycosa nidifex . . . 205
Lycosa nigroventris . . 203
Lycosa ocreata . . . 207
Lycosa pikei 204
Lycosa punctulata . . . 206
Lycosa scutulata . . 173, 206
Lycosa rufiventris . . 202
Lycosa relucens . . . 206

Mævia tibialis . . . 227
Micaria gentilis . . . 215
Micaria laticeps . . . 214
Micaria quinquenotata . . 215
Microneta denticulata . . 197
Microneta latidens . . . 197
Microneta persoluta . . 197
Microneta serrata . . . 198
Minyriolus 176
Myrmarachne albocinctus . 233

Neophanes pallidus . . 213
Neriene 176
New Species 178

Oecobius parietalis . . . 212
Orchestina saltitans . . 214
Oxyopes salticus . . . 173
Oxyopes scalaris . . . 212

Pachygnatha tristriata . . 202
Panamomops . . 176
Pardosa bilineata . . . 207
Pardosa diffusa . . . 208
Pardosa littoralis . . . 207
Peckhamia picata . . . 232
Peckhamia scorpionia . . 233
Pedanostethus pumilus . 183
Pedanostethus riparius . 182
Pedanostethus spiniferus . 183
Pellenes agilis . . . 230
Pellenes auratus . . . 230
Pellenes borealis . . . 231
Pellenes cœcatus . . . 173
Pellenes howardi . . . 228
Pellenes roseus . . . 229
Pellenes viridipes . . . 228
Phidippus albomaculatus . 224
Phidippus brunneus . . 224
Phidippus incertus . . . 224
Phidippus insignarius . . 225
Phidippus mystaceus . . 224
Phidippus whitmani . . 224
Pholcomma hirsuta . . 175
Pirata arenicola . . . 208
Pirata insularis . . . 208
Pirata maculata . . . 209
Pirata sylvestris . . . 209
Pocodicnemis . . . 176
Pœcilochroa montana . . 217
Prosopotheca 176
Prosthesima rufula . . . 217

Salticus albocinctus . . 233
Salticus ephippiatus . . 233
Scotolathys pallidus . . 213
Synemosyna picata . . 232
Synemosyna scorpionia . . 233

Tapinopa bilineata . . . 196
Tapinopa longidens . . 196
Tetragnatha vermiformis . 201
Thalamia parietalis . . 212

	page		page
Theridium cancellatum . .	184	Tmeticus flaveolus . . .	193
Theridium differens . .	180	Tmeticus longisetosus . .	192
Theridium kentuckyense .	180	Trachelocamptus . . .	176
Theridium verecundum . .	181	Typhocraestes	176
Theridium zelotypum . .	180		
Tmeticus	176	Zilla atrica	201
Tmeticus brunneus . . .	194	Zilla montana . . .	201
Tmeticus corticarius . .	194	Zygoballus terrestris . .	227
Tmeticus debilis . . .	193		

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 237-290 JULY, 1909

The Poems of Thomas Third Lord Fairfax

From MS. Fairfax 40

In the Bodleian Library, Oxford

BY

EDWARD BLISS REED

PUBLISHED UNDER THE AUSPICES OF
YALE UNIVERSITY

NEW HAVEN, CONNECTICUT
1909

WEIMAR: PRINTED BY R. WAGNER SOHN

IV.—The Poems of Thomas Third Lord Fairfax.

(From the Bodleian MS. Fairfax 40; formerly MS. Add. A. 120.)

In the annals of England the name of Thomas, third Lord Fairfax, is deservedly illustrious. As a general, he was an intrepid fighter and a skilful commander; in his private life, a man of scholarly tastes, happy in his country estates, which he preferred to the court. Policy and self-advancement were far from his thoughts, despite his great opportunities for aggrandizement; and the simplicity of his character, at which his enemies sneered, was but a proof of his sincerity. To sketch his life in detail is unnecessary, yet his poems will gain significance if, in the briefest manner, we review his interesting career.

The son of Fernandino, second Lord Fairfax, and Mary, daughter of Lord Sheffield, he was born at Denton, Yorkshire, in 1612, of a family long distinguished for its soldierly qualities. In 1620 his grand-father, Thomas, first Lord Fairfax, then a man of sixty, joined, with two of his sons, the single regiment sent by James I to the support of the Elector of the Palatinate. He was obliged to return to England to take part in the Parliamentary elections, but his two sons died at Frankenthal at the head of their troops. Fernandino did not make this campaign, and his father spoke of him as a "tolerable country justice, but a mere coward at fighting"[1]; yet Fernandino took the field against Charles I, and certainly did not deserve this taunt.

The early years of our poet were spent in Yorkshire, and he undoubtedly enjoyed in his first studies the guidance of his great uncle, Edward Fairfax, the translator of Tasso. In 1626 he entered St. John's College, Cambridge, where he remained four years, and then, following the family traditions, he went to the Low Countries, to serve under Lord Vere against the Spaniards. Another young volunteer in the same camp was Turenne. After witnessing the capture of Bois-le-Duc, he traveled and studied in France for eighteen months, returned to England in 1632, and requested permission to volunteer under Gustavus Adolphus, but his family opposed it, and he retired to the Yorkshire estates to live the life of a country gentle-

[1] *A Life of the Great Lord Fairfax*, by Clements R. Markham, London, 1870, p. 12

man. In 1637 he married the daughter of his commander, Anne Vere, a woman of energy and courage, who followed her husband to the field, shared his dangers (she was once taken prisoner by the Royalists) and, in no small measure, determined his career.[1]

In the two brief and inglorious Scottish compaigns, Fairfax joined the King's army, but when in 1642 Charles came to Yorkshire to seize the supplies at Hull, and raise troops against Parliament, the Yorkshire gentry who opposed the King looked to Fairfax for leadership. He was entrusted with a formal protest against the King's actions, and, despite repulses, succeeded in laying this document on the royal saddle at Heyworth Moor, where Charles was endeavoring to win over the gentry of the shire. Fairfax thus showed the world on which side he would be found, and in the Yorkshire campaign that followed, he fought with the greatest courage. Undaunted by defeat, fearing no odds, on at least one occasion he attacked a force that outnumbered his own by four to one. When surrounded, he cut his way through the enemy. At Marston Moor he found himself carried by the tide of battle into the thick of the enemy's ranks. Taking from his hat the white badge worn by the Parliamentary forces, he calmly rode through the ranks of the Royalists, regained his troops, and led another attack.[2] So fearless was he that on several occasions he narrowly escaped death. In 1644 a musket-ball pierced his shoulder, another broke his arm. Hardly recovered from these wounds, he was again struck at the siege of Pomfret Castle. His skill as a leader, his bravery in action, had attracted the attention of all England, and in 1645, when but thirty-three years of age, he was made Commander-in-chief of the Parliamentary forces, having as his first task the organization of the New Model army. While in the popular opinion it was Cromwell who was "the leading spirit of the war," to quote Sir Clements Markham, the biographer of Fairfax, "it was Fairfax who organized the new army without the smallest assistance from Cromwell. It was Fairfax whose genius won the fight at Naseby, and whose consummate generalship concluded the war, and restored peace. Cromwell was his very efficient general of horse, but nothing more: and indeed he was generally employed on detached duties of secondary importance."[3] At Naseby, Fairfax was conspicuous for his daring; at the surrender of Oxford, he placed a guard about the

[1] *Ibid.*, p. 108.
[2] *Ibid.*, p. 171.
[3] *Ibid.*, Preface, p. iv.

Bodleian and saved it from destruction, as he had spared the minster at the siege of York.[1]

With Charles hopelessly defeated, Fairfax was unwilling to depose him, wishing the King to rule, with the constitution safeguarded from encroachments of the crown. He hotly resented the seizure of Charles by Joyce, and through his insistance Charles was allowed to see his friends, and above all, his children—a favor for which he repeatedly thanked Fairfax.[2] In the political intrigues which preceded the execution of Charles, Fairfax took no part; but when the Royalists made a last stand, he laid siege to Colchester, captured the town, and crushed the insurrection. It was at this time that Milton addressed to him his noble sonnet:

> Fairfax, whose name in arms through Europe rings,
> Filling each mouth with envy or with praise,
> And all her jealous monarchs with amaze,
> And rumours loud that daunt remotest kings,
> Thy firm, unshaken virtue ever brings
> Victory home, though new rebellions raise
> Their Hydra heads, and the false North displays
> Her broken league to imp their serpent wings.
> O yet a nobler task awaits thy hand
> (For what can war but endless war still breed?)
> Till truth and right from violence be freed,
> And public faith cleared from the shameful brand
> Of public fraud. In vain doth Valour bleed,
> While Avarice and Rapine share the land.

Though appointed one of the Commissioners to try the King, Fairfax refused to be present at the trial, and opposed it in vain. Surely there are few more dramatic moments in history than when Lady Fairfax rose in the gallery of Westminster Hall to protest against the trial, and to defend her husband's name. Indeed, so well known was Fairfax's opposition to the execution of the King that Cromwell accused the general of planning to rescue Charles.

In 1650 Lord Fairfax resigned his command, and returned to his estates at Nunappleton. On the death of Cromwell he decided that there would be anarchy unless Charles II returned and ruled. Lambert, with a disciplined army of ten thousand men, was on the

---

[1] *Ibid.* p. 271. Fairfax bequeathed to the Bodleian 28 manuscripts. See W. D. Macray: *Annals of the Bodleian Library, Oxford.*

[2] *Ibid.* pp. 290, 298.

field to oppose Monck, who, with an army of seven thousand, was on the point of declaring for Charles. Though ill and suffering intensely, Fairfax sent word to Monck that he would take the field in support of Charles. When he appeared, Lambert's troops deserted and flocked to their old commander, and thus, without a shot being fired, the Restoration was accomplished. It was fitting that Lord Fairfax should head the commission sent by Parliament to the Hague to invite Charles to return. No honors were conferred on him by the Merry Monarch—he sought none—and he retired to Yorkshire, where he died November 12, 1671, three years before the death of Milton.

It is not surprising that the letters of Fairfax, and his two *Short Memorials of the War*, should have been published, but it is strange indeed that a manuscript of 656 pages of verse, all in his own handwriting, should never have been carefully examined. This manuscript passed from the possession of the Fairfax family, and was owned successively by Ralph Thoresby, the Duke of Sussex, and Dr. Bliss of Oxford, from whose collection the Bodleian library, its present owner, purchased it in 1858. Archbishop Cotton, in his *Editions of the Bible and Parts thereof in English from the year MDV to MDCCCL,* Preface to the second edition, 1852, gave a table of contents of the manuscript, then in the possession of Dr. Bliss, and reprinted one of the paraphrases of the Psalms. Sir Clements Markham, in his *Life of Fairfax*, already cited, went further; for in the text of his work he reprinted three of Fairfax's poems,[1] and in an appendix gave ten more, wholly or in part, but as a historian, interested in the political, and not the literary life of the times, he made no study of the manuscript. Since Markham, I can not find that any one has examined these poems or published them.

We have no means of dating the poems, with the exception of the following:

Upon the New-built House at Apleton (1650), *To the Lady Cary upon her Verses on my deare Wife* (1665), *On the Fatal Day* (1649), *Upon the Horse which his Majestie Rode upon att his Coronation*

[1] *Life of Fairfax*, p. 352: *On the Fatal Day, Jan. 30, 1648*; p. 365, *Upon the New-built House at Apleton*: p. 384, *Upon the Horse which his Majestie Rode upon Att his Coronation.* Appendix A, pp. 415–427 contains the following: *Preface to the Psalms, Honny dropps* (excerpts), *The Solitude, The Christian Warfare* (excerpts), *Life and Death Compared together, Shortness of Life, Of Beauty, Upon a Patch Face, Upon an ill Husband*, and two of the *Vulgar Proverbs.*

(1660).[1] As these poems are written down in this order, it will be seen that their position gives no clue to the time of their composition, indeed, the very last poem in the manuscript is an eclogue, *Hermes and Lycaon*, by Edward Fairfax, who died in 1635.[2] If we refer Fairfax's translations from "good old Mantuan" to his student days, the poems certainly cover a period of forty years.

A perusal of the manuscript shows us at once that Fairfax is not a poet, but rather a man of poetic tastes, an admirer of verse. We have, then, no discovery of a neglected genius, and there will be no call for the Complete Works of Thomas Fairfax. It will occasion no surprise, therefore, that we have omitted a considerable amount of his poetry.[3] It will readily be seen that the chief defect in these poems is their poor technique. Fairfax had very little sense of rhythm; at times his ear seems absolutely untrained, and, though a multitude of corrections in the manuscript show how hard he struggled to improve his lines, yet his revisions are generally as awkward as his first rude draft. Few of his poems have any metrical charm, and when in his *Honey Drops* or *Vulgar Proverbs* he seeks to become epigrammatical, he lacks both point and finish. His best writing is seen in such a poem as *David's Lamentation*, or in the straightforward couplets of the *Christian Warfare*; however, it is not for his skill as a writer that Fairfax deserves attention, but for certain conclusions that may be drawn from the subject-matter of his lines.

Fairfax divided his poetry into religious and secular verse, the former occupying 551 pages out of 650, 388 of these being devoted to a metrical paraphrase of the Psalms. From the days of Wyatt and Surrey in England and Clément Marot in France, to "translate" the Psalms, or indeed to turn any part of the Scriptures into verse, was a pastime indulged in alike by the devout and by the profligate. A complete list of English writers who from 1500 to 1700 made metrical versions of any portion of the Bible has never been compiled. It would be a surprisingly large one, and, though Fairfax was a devout man, he was following a literary fashion as well as his own inclination in his paraphrase which offers so little that is

[1] The *Epitaph on A. V. dieing Younge* might be dated, were we sure that V. stands for Vere.

[2] As Markham published this in *Miscellanies of the Philobiblon Society*, vol. 12, 1868–9, I have not reprinted it.

[3] See table of contents of the MS. on page 249. With the exception of the Psalms, I have a copy of the whole MS. It is at the disposal of any one interested in it.

interesting that I have reprinted but four Psalms, enough to show his method.[1] In his hymns we notice most of all that he writes in an impersonal style, for we have in them no picture of his own mind, no account of his spiritual conflicts, his doubts, his defeats, or his victories. Religious verse is valuable in proportion as it shows us the soul of a man, and this is precisely what Fairfax does not attempt to do.

This same lack of the personal element in his writing is a marked defect of the secular verse also, for he gives us practically nothing of his own life, even in remote allusion. When we consider the great scenes he had witnessed, the part he had played in shaping the destinies of England, it is rather surprising that he should choose to write on *Envy*, *Temperance*, *Anger*. Surely he might have written with more spirit on Liberty, Tyranny, or Valor. He collects many popular proverbs, but he does not jot down the song of his soldiers. For a fighting man, how faint and unrealistic are such lines:

> As men besieged with mines about
> Ready to spring and ruing [*sic*] all,
> Hearing the alarm beat, runne out
> To th' assault and gard ther wall,
> And by the blast in ruins sinke
> Vanquist are when they least thinke.[2]

And yet they are quite unusual, so rarely does he refer to the shock of battle. As Fairfax does not tell us what he has felt, so he has little desire to write down what he has seen. Apart from all considerations of the immeasurable distance that separates Andrew Marvell's work from that of Fairfax, it is yet surprising that Marvell should describe Appleton House and the estates so fully, and that Fairfax, who delighted in them, should give us but a few faint lines on the new-built house. Similarly we should expect the sympathetic picture of the last moments of Charles to

[1] Markham, in his *Life of Fairfax*, p. 369, mentions another copy of Fairfax's version of the Psalms, owned by Mr. Cartwright of Aynho. I have not attempted to trace this. At the end of the MS. of the *Short Memorial*, at Leeds Castle, are versions of the 18th, 24th, 30th, and 85th Psalms. He prefaces Psalm 18 with the following: 'That I chuse this 18 Psalm let none think that I arrogate anything to myself, for farre be it from me to applie it otherwise than as David's triumph over his enemies.' See Markham's *Fairfax*, p. 415.

[2] *A Hymne to Christ the Messiah.*

come from the pen of the general rather than from the tutor of his daughter.[1]

To observe for one's self, to describe one's feelings, demands a certain amount of originality, and this is precisely what Fairfax lacked. The greater part of his religious verse was paraphrase, and we naturally look for translation in his secular poems. Pages 602–10 of the manuscript are taken, he tells us, from the French, the Italian, the Latin. With the exception of the Mazarinades, all these translations are directed against Rome, showing his strong Puritan sympathies. It is interesting to notice that when he translates Petrarch he does not choose the sonnets to Laura, but *The Character of the Romish Church.*[2] Petrarchism, brought in by Wyatt and Surrey a century before, had spent its force, and the lyrics of Philip Ayres, 1687, fill the last book that shows the old sway of the founder of the modern lyric.[3] As confirmation of Fairfax's lack of skill in writing, it is noticeable that he is unable to reproduce the sonnet form, and turns the quatorzains into poems of twelve lines.

Eight pages of translation, however, constitute but a small part of his secular verse. As we read it, we are impressed by the contrasts it shows, contrasts that can not be explained by assuming that certain poems are separated by long intervals of time. Lady Carey had written to Fairfax a metrical epistle on the death of his wife, and he felt called upon to answer it. Knowing his devotion to Lady Fairfax, we expect him to rise above himself under the inspiration of his grief, but his thought is so trivial, and so feebly expressed, that *To the Lady Cary Upon her Verses on my deare Wife* is one of the poorest poems. A few lines will show this more plainly than any comment:

Madam

Could I a Tribute of my thanks express
As you have done in love and purer verse,
On my best selfe then I might Justly raise
Your Elogy t' Encomiums of your Prayse
And soe forgett the Subject that did move
Me to a thankfulness as 't did you to love.
O 'twere to great a Crime but pray allow

---

[1] See Marvell's *Horatian Ode upon Cromwell's Return from Ireland.*

[2] Sonnets, *De Vario Argumento*, Nos. 14 and 16.

[3] *Lyric Poems, made in Imitation of the Italians, London*, 1687.

Wher I fall short but you have reached to,
Making that Good wisest of Kings hath said,
Th' Living's not soe Prayse-worthy then [*sic*] the dead.

A few pages further on, we come to a more formal elegy on Henry of Navarre.

Ah is itt then Great Henry soe fam'd
For taming men, himself by death is tam'd!
Whatt eye his glory saw, now his sad doome,
But must desolve in Teares, sigh out his Soule,
Soe small a shred of Earth should him intombe
Whos acts deserv'd pocession of the whole.

Though this poem has its defects, it is, on the whole, a better piece of writing than the elegy on Lady Fairfax. This consideration, together with the fact that Henry of Navarre was assassinated two years before Fairfax was born, and that there seems to be no special reason why he should lament his death, makes one suspect that the lines are a translation from the French. Such is the case, for I find that the poem is taken word for word from an elegy by Anne de Rohan which Fairfax read at the end of Agrippa d'Aubigné's *Histoire Universelle*, published 1626, for d'Aubigné does not quote the whole poem, and Fairfax translates only as much as he gives.[1] With this hint I have looked in the French literature of the period for the originals of the other poems. *On a Fountain* is a translation of an epigram of Malherbe that was a favorite one,[2] to judge from its appearance in a French anthology (*Les Délices de la Poésie Française*, 1615), while Fairfax's best poem, the one that gives the manuscript its title, is a translation of Saint-Amant's *La Solitude.* Other sources I have not found, but I feel convinced that many of the poems are translations, as for example, *Of a Faire Wife, to Coregio*, which is probably taken from the Italian. Others better read in Continental literature of the period may discover his models.[3]

We are now in a position to see the significance of these poems. They are not fine examples of English verse; they are rather to be regarded as documents that show us what an English gentleman

[1] *Histoire Universelle* par Agrippa d'Aubigné (Paris, 1879), Vol. 9, pp. 472–75.

[2] See *Oeuvres complètes* de Malherbe (Paris, 1862), Vol. 1, p. 225.

[3] Mr. Lewis C. Everard, Yale Phi Beta Kappa Fellow, 1908–1909, has searched in the Bibliothèque Nationale, Paris, for other French originals, but without results.

of the Caroline and Commonwealth period read and thought. They are like an old diary in which a great man has jotted down a list of the books he owns, or of poems he has memorized; they are like a package of old letters, in which the writer tells us of his favorite authors and his literary tastes. It is to be observed that this moralist, who mentions but one English writer—his great-uncle—turns to French literature. *La Solitude* is certainly not only Saint-Amant's best piece of work, but one of the finest French poems of the period, and the evident admiration of Fairfax for it speaks well for his taste. Though Saint-Amant had twice visited London and was possibly known there as a poet, only two other unimportant translations of his verse have been noticed in English literature.[1] It is worthy of mention that Saint-Amant himself had some very pronounced opinions concerning Fairfax, who probably never read the Frenchman's *Epigramme Endiablée sur Fairfax.*[2]

There is another interesting point concerning *La Solitude.* It is well known that in 1650 Andrew Marvell came to Appleton House as a tutor for Mary Fairfax. He had already written verse, but it had not been nature-poetry; his grotesque *Flecnoe* and his absurd verses *Upon the Death of Lord Hastings* have nothing of the meadow

---

[1] See A. H. Upham, *The French Influence in English Literature from the Accession of Elizabeth to the Restoration*, New York, 1908, pp. 345, 405, 409, 412 It is interesting to read Saint-Amant's brief reference to Ben Jonson in his *L'Albion.*

[2] Je crois qu'il doit bien estre en peine,
L'execrable tyran qui preside aux enfers,
Quand, dans les feux et dans les fers,
Il songe au noir object des foudres de ma haine;
Son vieux sceptre enfumé tremble en sa fiere main;
Il redoute Fairfax, ce prodige inhumain;
Il craint que ce monstre n'aspire
Au degré le plus haut de son horrible empire,
Le degré le plus haut est celuy le plus bas,
C'est où ce prince des sabats,
Des endroits les plus clairs aux endroits les plus sombres,
Tomba pour regner sur les ombres;
C'est la, dis-je, qu'il craint que par quelque attentat,
Que par quelque moyen oblique,
Fairfax n'aille du moins renverser son estat
Pour en faire une republique.
Et voila les raisons qui l'ont fait hesiter
Jusqu'à cette heure à l'emporter.

Oeuvres Complètes de Saint-Amant (Paris, 1855), vol. 1, p. 472.

in them. During the two years he spent at the home of Fairfax, Marvell wrote those nature-poems that determined his fame—*Upon the Hill and Grove at Billborow, Upon Appleton House, On a Drop of Dew, The Garden*—poems that show an observation, an appreciation of the earth, of flowers, birds and trees unsurpassed in all the works of his predecessors in English poetry, not excepting the very greatest, Chaucer, Spenser, and Shakespeare. That these poems were inspired not only by the beauty of Nunappleton, but by its owner's love and appreciation of poetry, there can be little doubt. We may go even further, and see in Marvell's nature-poems some hints from Saint-Amant. Marvell's verse is richer and deeper; where Saint-Amant is vague in his descriptions or conventional in his thought, Marvell is concrete and original; for it is the Englishman, and not the Frenchman, who uses *le mot précis*, and yet Saint-Amant's theme—to lose one's self in Nature—is the theme of *The Garden* and of the finest lines in *Appleton House*.

We see now the significance of the poems of Fairfax. They throw light on the character of a great Englishman; they remind us that the literary influence of *la ville lumière* was still powerful in England, that it had not died with the sonneteers; and they give us the atmosphere in which Andrew Marvell lived and wrote the tenderest, the sincerest, the deepest nature-poetry of the seventeenth century.

Yale College,
February 19, 1909.

Edward Bliss Reed.

TABLE OF CONTENTS OF MS. FAIRFAX 40.

The poems marked † are reprinted here. Those marked * are given only in part. The poems are printed as they stand in the MS. with no changes in the punctuation or spelling.

[Title] The Imployment of my Solitude. T. F. p. i.

† The Preface to the Psalmes. p. ii.
* Psalms 1 to 150, in verse. pp. 1–388. [p. 389 is blank.]
Songs of the Old and New Testament. pp. 390–479.
* Moses Songe. Exodus 15. p. 390.
Moses Songe. Deut. 32. p. 396.
The Songe of Deborah. Judges 5. p. 406.
Hannah's Songe. 1 Sam. 2. p. 415.
† Dauids Lamentation for Saule & Jonathan. 2 Sam. 1. p. 418.
† Hezekiah's Songe. Isaiah 38. p. 422.
The Songe of Mary the Blessed Virgin. Luke 1. p. 427.
Zachariah's Songe. Luke 1. p. 429.
† Simeon's Songe. p. 431.
* The Songe of Salomon. Chapter 1. p. 432. Chapt 2. p. 435.
Chapt 3. p. 438. Chapt 4. p. 440. Chapt 5. p. 444.
Chapt 6. p. 448. Chapt 7. p. 451. Chapt 8. p. 454.
Out of the Prouerbs of Salomon. p. 458.
Wisdom's Antiquity. pp. 471–475.
Out of the Prouerbs of Salomon. p. 473[b] 473[c].
[These two pages were formerly pasted together. They are a repetition of pp. 458 and 459. with two lines of 460.]
Samuel's Instruction from his Mother. Prouerbs 32. p. 476.
* Honny dropps. p. 480.
Hymnes to the Soueraine God. p. 510.
A Hymne to Christ the Mesiah. p. 519.
A Hymne to the Holy Ghost. p. 539.
† A Songe of Prayse. p. 549–551[a].
[Title] The Recreations of my Solitude T. F. p. 551[c].
† The Solitude. p. 552.
† Of a Faire Wife to Coregio. p. 564.
† Of Beauty. p. 568.
† Upon a Patch Face. p. 570.
Upon a Younge Virago. p. 571.
† Upon an ill Husband. p. 571.
† Of Envy. p. 572.
† Of Anger. p. 574.
† Of Virtue. p. 577.
Of Patience and Temperance. p. 579.

† Nature and Fortune. p. 582.
† The Christian Warfare. p. 583.
† Life and Death compared together. p. 590.
† Upon a Fountaine. p. 592.
† Upon the New-built House at Apleton. p. 593.
† Shortness of Life. p. 594.
† Epitaph on A. V. dieng Younge. p. 595.
† The Lady Caryes Elogy on my deare Wife. p. 596.
† To the Lady Cary Upon her Verses on my deare Wife. p. 598.
† On the Fatal Day, Jan. 30th, 1648. p. 600.
† Of Impartial Fate. p. 601.
Epitaph sur le Mort du Cardinal Mazarin. Epiodium. p. 602.
† A Carracter of the Romish Church by Francisco Petrarca, Laura Can. 106. p. 604.
Pontanus writes this Epitaph on Lucretia daughter of Alexander 6. p. 606.
Baptista Mantua reproving the wicked Life of Sixtus 4 maketh the Divel give him this Entertainement in Hell. p. 607.
Mantua Eclogae 5. p. 608.
Palengenus A Papist thus discribes the monstrous Corruptions of the Romaine Clargie. p. 609.
Upon Mr. Stanley's Booke of Philosophers supposing itt the Worke of his Tutor W. Fa. p. 611.
† Upon the Horse wch his Matie. Rode upon att his Coronation 1660. p. 612.
* Vulgar Proverbs. p. 613.
† The teares of France for the deplorable death of Henry 4 surnamed the Great. p. 641.
An Egloge maide by my uncle Mr. Ed. Fairfax in a Dialoge betwixt two Sheapards Hermes and Lycaon. p. 647.

[p. ii] The Preface to the Psalmes.

Vaine Fancy whether now darst thou aspire
Wth smoky Coales to light the holy Fire
Could thou indeed as wth the Phenix burne
In perfum'd flames & into Ashes turne
Thou might'st hope (vaine hope) yet once againe
To rise wth purer notions in thy Braine
But t'would nott serue for they would still be darke
Till from thyn Alter Lord I take a sparke
I need not then assend up any higher
In offring this to fetch another fire
Inspired thus may on my Muse distill
Dewes nott from Parnass but Herman's sweet Hill.

[p. 1] Psal 1

Blest is the man in walking daly shuns
Pernitious Councel that from th' wicked Comes
Nor to the sinners paths his steps doth bend
Or he yitt up to Scorners chaire assend
Who in the early morne & euening laite
On lawes deuine makes choyse to meditate
As by the runing streames the well sett tree
His fruit in season yeild, the iust shall be
Whos leafe shall neuer fade & what he doth
Shall thriue as itt & shal be fruitfull both
But wth the wicked itt is diffrent farre
As chaff tost in the Ayre, So they are
Nor shall he stand fore th' impartial Judge
Or mongst the iust who in sins way doe trudge

[p. 38] Psal 19

The heauens Lord the siluer studed frame
They are the Curious works thy hands declare
Time vnto time itt doth recount the same
To places most remote, ther voyce it heares
Ore all the earth ther arched Sphers extends
The Tun on's throne ther rises ther desends

As cherfull brid-grome in his nuptial state
Or actiue men to race wth ioy Come out
From East to West so runs he at that raite
Till his cirquitt rownd he'as gone about
All parts euen to thé wide Earths extreames
Both light & heat takes from his radent beames

[p. 39] Thy law ô Lord to soules perfection giues
They that are simple by thy words made wise
They shall reioyce who in thy precepts liues
Thy Statutes pure inlighten's the blind eyes
To feare the Lord will vs preserue for euer
Whos iudgments true & rightious altogether

More sweete then honny yea or gold refin'd
Thy seruants setts them att a hier prise
They great rewards in keeping them do find
But ô alas who ist his errors spies
My faults vnseene ô let ther none remaine
From bold-fac'd sins thy seruant Lord restraīe

[p. 40] O let not sin wth it's tyranick might
Ére gitt a iuri[s]diction ouer mee
So in my soule shall I then be vpright
And from the great transgression guiltless be
So shall my words & thoughts acceptance find
W^th^ thee my strength redeemer of man-kind

[p. 49] Psal 23

How can I want the Lord my sheapard seemes
Who to the verdant pasturs leads me outt
By flowry bankes wher waters gently streams
My soule he doth refresh he sets my foot
In paths of truth & eaqual Justice both
This only for his owne name sake he do^th

Al Though I through death[s] shady vale doe goe
No terrors ther shal makes me yitt affraid
His rods my guide his staff my strength also
Befôre myn foes my table he doth spread
W^th^ oyle my head full cups my hart doth chere
Him in his house for euer I'le serue ther

[p. 104] Psal 46

If in distress ô Lord thou 'lt giue me ayde
What need I feare though rocks in seas be throwe
Though by ther rage the hills on hills be layd
Thou still preseruest thos that are thyn owne
In thes o're turnings shal noe fear cease them
For God was ther, his help in season Came

When furious rage procest the Heathen world
Thou was to vs as a strong Towre in War
Thou spake the word & Earth on heaps was hurld
Come se then ther what great vastations are

[p. 105] T'is he when wars arise Can stop ther Course
This he ther weapons breake ther Chariots fire
Wait thou on him know he's a God of force
Did he not rule the world t' would soone expire
He mongst the Heathens will exalted be
But Jacobs Gods the Towre to whom we flee

[p. 390] Songs of the Old & New Testiment

Moses Songe
Exodus 15

Vnto the Lord let prayse be sung
Who gloriously triumphed hath
For he into the sea hath flung
Both Horse & Rider in his wrath

The Lord my strength & songe shall be
Who my sure saluation
Mine & my father's god is he
Soule be his habitation

[p. 391] A man of Warr's the Lord renown'd
His name is by Jehouah knowne
Who in the Sea hath Pharoah drownd
Downe Captains Horse & Chariots throwne

This goodly Traine wth fury drunke
The waues as Couerings did Containe

Wher to the bottome they are sunke
As stones that neuer rise againe

Thy hand o Lord has done this deed
Glorious in Powre art thou become
Thy hand I say when ther was need
Th' insulting Foe has ouercome

[p. 392] They that agaīst thee did Combine
Thy wrath has broke in thy defence
As stuble th'are before the winde
So powrefull is thyn' excelence

Thy Nosthrills wth a blast haue layde
The liquid Seas on sollid heapes
The floating waues ther wth were stay'd
As Ice Congealed in the depths

Pursue o'retake th' enimy said
Ther spoyles let vs mongst vs deuide
Whilst wth ther Swords they hauack made
And lust as law to them was guide

[p. 393] But in a happy howre thou did
The Treasures of thy winde display
So sunk they as the heauy lead
And vnder watry-Monntains lay

Amongst the Gods who's like to thee
O Lord in Holiness & Prayse
The fearfull wonders wch we see
Doe Trophyes to thy Glory raise

Thou stretcht thy hand & they were gone
The gapinge earth deuourd them quite
To th' Holy mountaine thou leddst on
The chosen Flock of thy delight

[p. 394] Nations hard this wth pale-fac'd looks
And horred feare amazed stood
Edom Moab & Syrian Dukes
Ditt melt away wth Canan's broode

Thy Glorious Name did soe apall
Ther trimbling Harts wth feare & dread
That as a stone lie still they shall
Till those pass ouer thou dost lead

To Zions mount thou didst them bring
Didst plant them in its firtil soyle
The place wher thou delightst in
A sanctuary freed from toyle

[p. 395] Raigne Lord for euer vn-opposd
For Pharoa's Horse & Men are drownd
Him & his force hath sea inclosd
Whilst Israel marches on dry grownd

Miriam the Prophetiss a Timbrel takes
Wher in their Circulinge-dances round
The Virgin-Traine such Musick makes
As th' Hills about wth Ecchoes sound

Then Miriam answered them & sunge
The Lord triumphd in Glory hath
Proud Pharoah into th' sea has flunge
W^th^ Horse & Rider in his wrath

[p. 418] Dauids Lamentation for Saule & Jonathan.

2 Sam: 1

Israel has lost her ornement
Alas for itt lement
How are her Mighty, falne & laine
& on Mount Gibea slaine
Ô let itt nott in Gath be knowne
Or told in streets of Askelon

O lett nott Lord our ancient Foes
Joying Deride our woes
Least daughter of th' vncircomcis'd
Triumph o're vs dispis'd
[p. 419] Noe more lett fruitfull showres distill
Or dewes on Gibeas direfull Hill

Nor e'er may any thither bringe
More a Heaue-Offringe
Ther th' Mighty fell, Saule lost his sheild
In this shamfull feild
On him regardless they did treade
As if noe oyle had touch'd his head

Sharp Arrowes shott from Jonathans Bow
Drunk wth the blood of Foe
Nor did Sauls sword rebate a Jott
Till he'ad his[1] enimys smote
[p. 420] How louely-pleasant are you tow
Death Could not loue disjoyne in you

Swifter then Eagles wch th' Ayre peirce
Both stronge as lions feirce
Israel's daughters lement the fall
Of your valiant Saule
Who you in Purple & Scarlet deckt
And did from Foes your land protect

How pleasant was itt to behold
Your orniments of Gold
Thy worthys by the sword, how are
They thus cutt off in war

[p. 421] O Jonathan my harts delight
Slaine in the bloody fight
Mount Giboa saw the woefull day
Thou mongst her Rockes ther wounded lay

How can I Deare Jonathan express
For thee my sad distress
Noe Woman's loue reach'd thatt degree
As thou once loued mee
How is the Mighty falne, is Crusht
And Israels Worthys rould in dust

[p. 422] Hezekiahs-Songe

Isaiah 38

In Cuttinge off my days I said
Must I goe downe to deaths cold shade
Youth's flowre noe sooner Budd but Blast
Be Cropt and to obliuion cast
Mongst liuing Lord must I noe more
Lift vp myn eyes & thee adore

[1] Fairfax has written over this line "his foes had smote."

Or longer in this vniuerse
Wth Man-kind haue noe more Conuerse
Farwell then Suns chearful light
Whose Rayes expells the shades of Night
[p. 423] Adeiu deare siluer-Horned Moone
By step & step our time setts downe
Yee Stars farwel that in Night appears
Runing in your apoynted Spheres
Who from your orbs soe far from hence
Throwes downe on vs your influence
Stay when you will your Constant Course
For ouer death you haue noe force
Farwel my Friends, farwel delight
Deuided by Eternal Night
My flitting years how soon th'are spent
Remoued as a Sythian Tent
Here to day to morrow dead
[p. 424] Cut off like to a weauers thread
In morning when new hopes began
Er' euening pinning sickness came
Yitt did'st nott heare my sad groanes
But lyon-like brake all my bones
O whatt a little space is this
T'wixt Being & not Beinge is
Euen from th' Eueninge to the Day
My wasting Sperits faide away
As Crane or Swallow sett alone
To the ô Lord I make my mo'ne
And as the Doue that trembling sitts
When Hawke aboue doth sores his pitch
[p. 425] So faints my hart so failes myn eyes
In seing such sad miseryes
But thou in Mercy hast noe piere
O help me in this troubled feare
What shall I say but sure thus much
Thy Word & Truth keep perfait touch
For sin my soule shall all itts days
Walke softly in my pensiue wayes
By these things Lord doe Mortals liue
New life by these things thou dost giue
Lo, Peace to me dost thou restore
And Joy for Greefe I had before

Thou pluckt me from destrctions Pitt
[p. 426] And all my sins didst thou remitt
For who in death can offrings bringe
Or in the Graue thy Prayses singe
Of All to Shades beneath repare
Does any hope for Mercy ther
The liuinge 'tis the liuinge They
Shall Prayse thee as I doe this day
Father to sonne relate shall this
How faithfull are thy Promises
Since Lord thou hast prolong'd my days
On Warbling Harpe I'le giue thee prayse
And in thy Courts wth Holy Fire
Of Zeale pay thanks till I expire

[p. 431] Simeon's Songe

As thou hast said soe Lord pray I
In peace now lett thy seruant die
Sence my blest eyes haue seene i'th end
Saluation from thy Throne desend
Which thou before earth frame was layd
To saue Man-kind decreed had
A light to guide the Gentiles ways
Of Israel's sones to be the prayse

[p. 435] [The Songe of Salomon]

Chap 2

I am the Rose of Sharon's fruitfull feild
The Lilly wch the humble vallyes yeild
In midst of thornes as Lilly appear's aboue
Soe mongst the youthfull Virgins is my loue
As Apple-trees 'mongst trees o'th Forrest growe
Amongst the sones of Men my loue is soe
Vnder whose shade is my delightfull seat
And to my tast his fruit is pleasant meat
Then to the house of wines he brought me in
Wher Loue like banners was a Couer in
Stay me wth flaggons wth Apples Comfort giue
Who's sick of Loue may yitt haue hope to liue

Vnder my head his left hand stretched out
And wth his Right h' imbraceth me about
[p. 436] O Zions daughters I strictly you adiure
By the swift Hynde & fearfull Roe be sure
Noe stir by noyse you make for to disease
Or wake my loue before the time he please
Behold I hear his Voyce o're Hills & Downes
My loue Comes skiping ouer Mounts & bounds
Like th' Hart or nimble Fawne & triping Roe
Standing behind our Wall Behold him Loe
Through trelest windows how he looketh out
His Church wth watchfull care he vews about
Thus speaking to me I my loue did heare
Arise my faire one Come away my deare
Lo winters past wth her stormy showers
Th' Earth now shew's her various coulred flowrs
Chirping of birds a signe the spring grows near
[p. 437] We in the land the mourning Turtle heare
The Figg-tree budding green her Figgs disclose
The tender Grapes of Vines smell as the Rose
Arise my faire one Come away my loue
Whom Cliffy Rocks doe hid Come out my Doue
Shew me thy Face myn eares let thy Voyce meet
Thy Countinance is Comely, Voyce most Sweet
Take th' Fox & little Foxes in thy Toyles
That thus our tender grapes & Vinyard spoyles
My deare is myne & I am his who 'monge
The Lillyes feed till shades of Night be gone
Turne my beloued turne like th' Roe that trips
Or nimble Hinde that in Mount Bether skips.

[p. 480] Honny dropps.

(Under this title Fairfax has written
one hundred and twenty five couplets and thirty five quatrains)

Why good men haite all sin 'tis understood
Because tis both gainst god and ther owne good

To walke wth god tis goodmen's care we see
But leaves the Care to god wch way 't should be

Noe safty wth out god in Freindship were
Yitt safe wth enimyes if God be there

[p. 482] A good man questionless was never hee
Thatt strives nott allways better for to be

[p. 483] Good Conscience is a name att wch Men tante
But betters a good name then Conscience want

[p. 484] Whatt before men we are affrayd to doe
Fore God to thinke itt should affright us too

Many the Sacred ordinances use
Making noe proffet of them—them abuse

[p. 486] When thou dost well or any good thou can
Prayse nott thy worke, the worke will prayse the Man

[p. 487] The soule by such a Noble sperit moves
Tis nott soe much where't lives as wher it loves

Sure best are they, nott they who most can talke
How Good God is, but who most with him walke

[p. 490] In sweetest Natures this will sure befall
None All can like nor shall be lik't of all

[p. 491] All Earthly things are such as ther's noe doubt
Worst Men may have and best may goe wthoutt
Yett wanting them a man may happy be
When others wth them have butt misery

[p. 492] Noe Time in pastime need we Idly wast
For time will pass from us in too much hast

[p. 507] I'th' Sacred Arke Reason of State should lye
But rules of state should nott Religion tye

When men wth wine themselves like beasts abuse
Not wine the Men but the wine misuse

[p. 509] In all thou undertskes be carful still
That none of thee can speake deserved ill
And soe when that is done thou needs not Care
For Ill men's Censure (Tis the Common fare)

[p. 549] A Songe of Prayse

Earth prayse the Lord him Reverence beare
As well for's Thunders that we heare
At wch poore Mortals stand affraid

As four the glotious Maruels which
Such Splendors doth the world inrich
They are the workes his hands hath made

His Prouidential loue lets singe
That wth a plentious flowinge springe
Our barren soules hee watered

The East the West tast of his Care
Hott Affrick nor the freezinge Beare
From his al seeinge eye is hidd

[p. 550] And wast nott he He who did please
W^th^ seueral kinds to store the Seas
Of Fish beyond account Nay more

Made Woods & Hills that Cataile yeilds
Gaue flowry Pasturs verdent feilds
That bringe both Corne & wine great store

But how doe we his mercy wronge
He sees wee still in Sin grow stronge
And day by day his patience moue

Yet as a Father ready is
To pardon faults he sees in his
Such are the tokens of his loue

[p. 551[a]] In vs Affections ôh tis strange
W^th^ our light humor suddaine Change
As in a moment they grew old

They wth the Wind are easely driuen
But his is alweyes firme & euen
And to Eternity doe hold

Finis

[p. 551 c] THE RECREATIONS OF MY SOLITUDE

T : F

[p. 552] THE SOLITUDE

O how I loue these Solitudes
And places silent as the Night
Ther wher noe thronging multituds
Disturbe wth noyse ther sweet delight
O how myn eyes are pleas'd to see
Oakes that such spreadinge branches beare
W^ch^ from old Time's netiuity
And th'enuy of so many yeares
Are still greene beautifull & faire
As att the world's first day they were

Naught but the highest twiggs of all
Wher Zephyrus doth wanton play
[p. 553] Doe yett presage ther future fall
Or shew a signe of ther decay
Times past Fawnes Satyrs Demy-Gods
Hither retird to seeke for Aide
When Heauen wth Earth was soe att odds
As Jupiter in rage had laide
O're all a Deluge these high woods
Preseru'd them from the sweling floods

Ther vnder a flowry Thorne alonge
Of Springs delightfull plant the Cheife
Sadd Philomela's mournfull songe
Doth sweetly entertaine my greefe
And to behold is noe less rare
[p. 554] These hanging Rocks & Precepies
W^ch^ to the wounds of sadd dispare
Are soe propitious to giue ease
When soe oprest by cruel fate
Death's sought for att another gate

[LA SOLITUDE [1]

A Alcidon.

Que j'ayme la solitude!
Que ces lieux sacrez à la nuit,
Esloignez du monde et du bruit,
Plaisent à mon inquietude!
Mon Dieu! que mes yeux sont contens
De voir ces bois, qui se trouverent
A la nativité du temps,
Et que tous les siecles reverent,
Estre encore aussi beaux et vers,
Qu'aux premiers jours de l'univers!

Un gay zephire les caresse
D'un mouvement doux et flatteur.
Rien que leur extresme hauteur
Ne fait remarquer leur vieillesse.
Jadis Pan et ses demy-dieux
Y vindrent chercher du refuge,
Quand Jupiter ouvrit les cieux
Pour nous envoyer le deluge,
Et, se sauvans sur leurs rameaux,
A peine virent-ils les eaux.

Que sur cette espine fleurie,
Dont le printemps est amoureux,
Philomèle, au chant langoureux,
Entretient bien ma resverie!
Que je prens de plaisir à voir
Ces monts pendans en precipices,
Qui, pour les coups du desespoir,
Sont aux malheureux si propices,
Quand la cruauté de leur sort
Les force à rechercher la mort!

[1] This is not in the MS. See pp. 246–248.

How pleasant are the Murmuring stream
In shady Vallyes runinge downe
Whose raginge torrents as itt seemes
Just measurs keepe in skpps & bounds
Then glidinge vnder th' arbored banks
As windinge Serpents in the grass
The sportfull Naides playes ther pranks
[p. 555] Vpon the watry plaines of Glass
The christal Elements wherin
These watry Nimphes delight to swime

The quiet Marshe I loue to see
That bounded is wth willowes round
With Sallow, Elme, & Popler tree
W^ch^ Iron yett hath giuen noe wound
The Nimphes that Come to take fresh Ayre
Here Rocks & Spindles them prouide
Mongst Sedge & Bulrush we may heare
The lepinge Froggs Se wher they hide
Themselues for feare when they espye
A Man or Beast approachinge nye

[p. 556] A hundred thousand Fowle her lye
All voyd of feare makinge ther Nest
Noe treachrous Fowler here Comes nye
W^th^ mortal gunnes to breake ther rest
Some ioying in the sunn's warme beames
Ther fethers buisily doe plume
Whilst others findinge Loue's hott flames
In waters allsoe can Consume
And in all pastimes Inocent
Are pleased in this Element

How pleasant is itt to behold
These ancient Ruinated Towers
[p. 557] 'Gainst wch the Giants did of old
W^th^ Insolence imploye ther Powers
Now Sayters here ther Sabath keepe
And Sperits wch our sence inspire
W^th^ frightinge dreames whilst we doe sleepe
Noe here againe all day retire
In thousand Chinkes & dusty holes
Lyes vgly Batts & Scritchinge Owles

Que je trouve doux le ravage
De ces fiers torrens vagabonds,
Qui se precipitent par bonds
Dans ce valon vert et sauvage!
Puis, glissant sous les arbrisseaux,
Ainsi que des serpens sur l'herbe,
Se changent en plaisans ruisseaux,
Où quelque Naïade superbe
Règne comme en son lict natal,
Dessus un throsne de christal!

Que j'aime ce marets paisible!
Il est tout bordé d'aliziers,
D'aulnes, de saules et d'oziers,
A qui le fer n'est point nuisible.
Les Nymphes, y cherchans le frais,
S'y viennent fournir de quenouilles,
De pipeaux, de joncs et de glais;
Où l'on voit sauter les grenouilles,
Oui de frayeur s'y vont cacher
Si tost qu'on veut s'en approcher.

Là, cent mille oyseaux aquatiques
Vivent, sans craindre, en leur repos,
Le giboyeur fin et dispos,
Avec ses mortelles pratiques.
L'un, tout joyeux d'un si beau jour,
S'amuse à becqueter sa plume;
L'autre allentit le feu d'amour
Qui dans l'eau mesme se consume,
Et prennent tous innocemment
Leur plaisir en cet element.
. . . . . [1]

Que j'ayme à voir la décadence
De ces vieux chasteaux ruinez,
Contre qui les ans mutinez
Ont deployè leur insolence!
Les sorciers y font leur sabat;
Les demons follets s'y retirent,
Qui d'un malicieux ébat
Trompent nos sens et nous martirent;
Là se nichent en mille troux
Les couleuvres et les hyboux.

[1] Fairfax omits a stanza here.

These Mortal Augurs of Mischance
Who funerall notes as Musick makes
The Goblins singe & skipp & dance
In valts ore spred wth Toads & Snakes
Ther in a Cursed beame might see
[p. 558] The horred Skeliton of some poore louer
W^ch^ for his Mistriss Cruelty
Hanged himselfe sence naught could moue her
Or wth a glance nott once to daine
To ease him of his mortal paine

The Marble Stones here strew'd about
Of Carracters leaue yett some signe
But now are almost eaten outt
By teeth of all deuouring time
The planks & timber from aboue
Downe to the lowest Valts are fau'ne
Wher Toads & Vipers 'mongst them moue
Leauinge theron ther deadly spawne
[p. 559] And Harths that once were vs'd fvr fyers
Now shaded are wth scratchinge Bryers

Yet lower an Arched-Valt extends
Soe hiddious darke & deepe doth sinke
That did the Sun therin desend
I thinke he scarce Could se a winke
Slumber that from heauy Cares
W^th^ drowsiness inchants our sence
Sleepes here secure, as far from feares
Lul'd in the Armes of Negligence
And on her back in sluggish sort
Vpon the pauement lyes & Snort

[p. 560] When from these Ruings I doe goe
Vp an aspiringe Rock nott farre
Whose topp did seeme ast were to know
Wher mists & Stormes ingendred are
And then desending att my leasure
Downe paths made by the storming Waues
I did behold wth greater pleasure
How they did worke the hollow Caues
A worke soe Curious & soe rare
As if that Neptuns Court were ther

L'orfraye, avec ses cris funebres,
Mortels augures des destins,
Fait rire et dancer les lutins
Dans ces lieux remplis de tenebres.
Sous un chevron de bois maudit
Y branle le squelette horrible
D'un pauvre amant qui se pendit
Pour une bergère insensible,
Qui d'un seul regard de pitié
Ne daigna voir son amitié.
. . . . . [1]

Là se trouvent sur quelques marbres
Des devises du temps passé;
Icy l'âge a presque effacé
Des chiffres taillez sur les arbres;
Le plancher du lieu le plus haut
Est tombé jusques dans la cave,
Que la limace et le crapaut
Souillent de venin et de bave;
Le lierre y croist au foyer,
A l'ombrage d'un grand noyer.

Lá dessous s'estend une voûte
Si sombre en un certain endroit,
Que, quand Phebus y descendroit,
Je pense qu'il n'y verroit goutte;
Le Sommeil aux pesans sourcis,
Enchante d'un morne silence,
Y dort, bien loing de tous soucis,
Dans les bras de la Nonchalence,
Laschement couché sur le dos
Dessus des gerbes de pavos.
. . . . . [1]

Tantost, sortant de ces ruines,
Je monte au haut de ce rocher,
Dont le sommet semble chercher
En quel lieu se font les bruïnes;
Puis je descends tout à loisir,
Sous une falaise escarpée,
D'où je regarde avec plaisir
L'onde qui l'a presque sappée
Jusqu'au siege de Palemon,
Fait d'esponges et de limon.

[1] Fairfax omits a stanza here.

Tis a delightfull sight to see
Standinge on the muṙuringe shore
[p. 561] When Calmer Seas begin to bee
After the Stormes wᶜʰ raginge roare
How the blew Trytons doe appeare
Vpon the rollinge Curled Waues
Beatinge wᵗʰ hiddious tunes 'the Ayre
Wᵗʰ Crooked Trumpets Sea-men braues
Att whose shrill notes the winds doe seeme
By keepinge still to beare esteeme

Sometimes the Sea wᵗʰ Tempests rore
Frettinge itt Can rise noe higher
Roulinge or'e the flinty shore
Throwes them vp againe retirés
[p. 562] Somtimes through itt's deuouringe Jawes
When Neptun's in an angry moode
Poore mariners finde his Cruel lawes
Made to his finy Subiects foode
But Diamonds Amber & the Jett
To Neptune they doe Consecrate

Sometimes soe Cleare & soe serene
Itt seemes ast were a looking glass
And to our Vewes presenting seemes
As heauens beneath the waters was
The Sun in it's soe clearely seene
That contemplatinge this bright sight
[p. 563] As't was a doubt whether itt had beene
Himselfe or image gaue the light
Att first appearing to our eyes
As if he had falne from the skyes

Thus Alcidon whose loue inioynes
To thinke for thee noe labor paine
Receaue these Rustick Shepheards lines
That's from ther liuinge obiects ta'ine
Sence I seeke only desart places
Wher all alone my thoughts doe use
Noe entertainment but what pleases
The genius of my Rural Muse
But noe thoughts more delighteth mee
Then sweet Remembrances of thee

Que c'est une chose agreable
D'estre sur le bord de la mer,
Quand elle vient à se calmer
Après quelque orage effroyable!
Et que les chevelus Tritons,
Hauts, sur les vagues secouées,
Frapent les airs d'estranges tons
Avec leurs trompes enrouées,
Doat l'eclat rend respectueux
Les vents les plus impetueux.

Tantost l'onde, brouïllant l'arène,
Murmure et fremit de courroux,
Se roullant dessus les cailloux
Qu'elle apporte et qu'elle r'entraine.
Tantost, elle estale en ses bords,
Que l'ire de Neptune outrage,
Des gens noyez, des monstres morts,
Des vaisseaux brisez du naufrage,
Des diamans, de l'ambre gris,
Et mille autres choses de pris.

Tantost, la plus claire du monde,
Elle semble un miroir flottant,
Et nous represente à l'instant
Encore d'autres cieux sous l'onde.
Le soleil s'y fait si bien voir,
Y comtemplant son beau visage,
Qu'on est quelque temps à sçavoir
Si c'est luy-mesme, ou son image,
Et d'abord il semble à nos yeux
Qu'il s'est laissé tomber des cieux.

Bernières, pour qui je me vante
De ne rien faire que de beau,
Reçoy ce fantasque tableau
Fait d'une peinture vivante.
Je ne cherche que les deserts,
Où, resvant tout seul, je m'amuse
A des discours assez diserts
De mon genie avec la muse;
Mais mon plus aymable entretien
C'est le ressouvenir du tien.
. . . . . [1]

[1] Fairfax omits the two concluding stanzas.

[p. 564] Of a Faire Wife

to Coregio

Thou thinkst Coregio thou hast gott
An exelent Beauty to thy lott
But yet remember this againe
For pleasure also thou'lt haue paine
No perfect rest can be to thee
When watchfull always thou must be
T'is hard & difficult to keepe
That all the world desire & seeke
Is her beauty much, Then know
Her pride's noe less wch she doth show
[p. 565] Dost thou admire her th'more will shee
For thy esteeme disdainfull be
But is shee faire Consider this
If shee be chast, some doubt it is
As shee in hansomnes exceeds
Soe much of Modesty shee needs
Shee'l alwayes be a Mistress there
Wher only thou Comand should beare
But wouldst thou haue me to define
This rare beauty that is thine
Thy Idoll as thou make's of itt
Much more of Hurt then good thou'le gett
[p. 566] For th' Adoration by thee giuen
Giues thee a Hell insteade of Heauen
New habits daly shee will axe
And if denyed then shee will vex
And thinke all's nothing in her passion
That's nott in the Mode & fashion
As if her Body were assign'd
To giue Inquietud's to thy minde
Me thinke I see thee rauisht on her
Thou blinde (as Idolizinge) Louer
Ma'as soone begett Ixion's brood
On Juno's Image in a cloude

[p. 567] Why shouldst thou longer thus submit
To her who to obay's more fitt
Least when thy Reason once is lost
Thy Liberty too itt will Cost
And in the end butt as a slaue
A soueraine for Companion haue
To say noe worse of Beauty I Conclude
It is but an Ilustrious seruitude

[p. 568] Of Beauty

Beauty's a fraile & brittle good
W^ch^ Sicknes Time & Age doe blast
The Rose & Lilly in face thatt budd
Hardly are keept & seldome last
What hath she then to boast on Saue
A fragil life & timely graue

Beauty wher sweet Graces faile
May be Compared vnto this
A goodly ship wth out her saile
A spring her fragrant flower doe miss
[p. 569] A day want's Sun or Torch itts Light
A shrine want's Saint or Starless night

But how doth Nature seeme to smother
The Virtues of this louely Flower
Who is of wanton Lust the Mother
Of toyinge Vanity a Bowre
Enimy of Peace the Fount wher Pride doe swime
Th' Incendeary of Strife of Passions Magazen

[p. 570] Vpon a Patch Face

Noe Beauty Spots should ladyes weare
They but the Spots of beauty are
Who knowes nott this (saue foolish Sotts)
That Beauty aught to haue noe Spotts
Some note a Spot that Venus had
Admitt itt were in one soe badd
Yett should nott shee haue Spots vpon Her
That would be held a Maide of Honor

[p. 571] Vpon an ill Husband

All Creaturs else on Earth that are
Whether they Peace affect or Warre
Males ther Females ne're opress
By the Lyon safe lyes the Lyoness
[p. 572] The Beares ther Mates noe harme procure
W^th^ Wolfe the shee Woolfe liues secure
And of the Bull the Earth wch teeres
The tender Heyfer has noe feares
But men then these more brutish are
Who wth ther wiues Contend & jarre

[p. 572] Of Enuy

In Enuy's Face discerne I this
Of Monsters shee most Monstrous is
A hurtfull glance her eye doth dart
A painfull paine lies att her hart
[p. 573] Noe Good doe's Man enioy by Right
Her enuious teeth doth nott bitte
To Carracterize her yitt more fitt
Of Erringe blindness shee the Pitt
A Hell to Natures swetest Life
Reuenges Spur the flame of Strife
Her Actions yett bespeake her worse
To Ciuill Peace a vexinge Curse
Temptation's Sargent that's assign'd
The Sentinell of Restless minde
More hurtfull to the soule by farr
Then Vipers to the body are
But in a word t'express this Euell
T'is the Sin peculier to the Diuill

[p. 574] Of Anger

Noe Passion's rooted deeper or extends
Her branches furder or that more offends
Then Coller doth of wch no sex or Age
Can boast a full exemption from itts rage
And when it's boundless fury growes
It's high distemper Madnes showes

Soe oft as Man is Angery oh tis sadd
He's nott only weake but blinde & Madd
Error for Truth imbraces & t'wer well
If dearest freinds from enimys he Could tell
A harmeless smile or from the eye a glance
Though vndesign'd puts him into a trance
[p. 575] And when his fury wakes how oft tis seene
Frendships most sacred bonds disolued haue beene
Who doth nott then discerne in sundry fashions
How Man afflicted is wth Angry passions
More feirce then are some Brutes as may apeare
They sometimes yeilds but he's in full Cariere
As Mariners when wth amazement smitt
The Pilots voyce in stormes regards nott itt
Soe men in frenzy ther strange gesters are
Wild as the beasts & Irreguler
The flaminge fire wch Passions kindle flies
In furious sparkes from his piercinge eyes
His angry face by a reflux of blood
That from his Hart assends becometh rude
[p. 576] His haire wth gastly horror stands vpright
And euery word he speakes he seemes to bitt
His hands & feet in ther excentrick Motions
Breath naught but threats wth rash & bloody notions
His Lookes soe terrible as doe portend
A fatal Change vnto his nearest freind
What must be then's distempred soule wthin
Soe vgly outward, but a sinke of Sin

[p. 577] Of Virtue

As wel tun'd Musick sweetly seize
The sences soe doth't Virtue please
The Virtuous, force the Vitious too
Th'admire in others what they should doe
Those best loue virtue & her lawes
That most Contemnes men's vains aplaues
Vertue alone all Grace inhance
And she noe vse doth make of chance
Whose effects are transcent in th' euent
What proceeds from virtue's permenent

Those things itt slights the World doe hold
Pretious as Fortunes Goods & Gold
[p. 578] These hath ther wings & flye away
When Man desireth most ther Stay
The virtious Soule prize most that some
Thinkes but from sheepesh nature Come
And nott from Grace the spring frõ whence
Flowes Virtue Goodnes Inocence
Care thou for these sence they'le apeare
Much surer Goods then Riches are
Thy virtious acts goe wher thou will
For Companions thou shalt haue still
When Men shall faile & freindship both
A better frende wth thee then goe'th
Enuy att death shal Cease in Foes
No Post-hume euel Malice knowes
[p. 579] In transendent hight shal vertue shine
Wher feet of Enuy Can not clime
Virtue alone doth death outliue
As't t'wer againe new life doth giue
Whilst Goods of Fortune here haue ends
Virtue alone to heauen assends

[p. 582] Nature & Fortune

What thing is nature we may thus define
God draws't through Beings in directst line
Wher as in Fortune soe miscal'd by some
More Crooked is & in Meanders rune
As Natur's rule by prouidence deuine
Soe Fortune too in an obstrucer line
Then Fortune is not blinde as vaine men says
Tis they are blinde discerning not her wayes

[p. 583] The Christian War-fare

The marke of note Gods children here doe beare
Is from the World's a different Carrecter
He to th'one for portion here beneath
Doth Losses, Shame & Pouerty bequeath

Yett happy those Aflictions wee account
That to the State Eternal doe amount
The worldly brood if we Caractrize
Th' haue noe Aflictions liue in Paridize
Ther Riches here as they desire augment
Ther Honors too increase to ther Content
But as a dreame these Honers vanish soone
And an eternal woe shal take ther Roome
As fatt of Lambes away they shall Consume
Ther Honor vanish into smoke & fume
[p. 584] T'indure sorrowes & Iniuryes we must
(As Scriptures tel) & be to exile thrust
Then tis a signe indeed heauen is our choyse
When in our Tribulations wee reioyce
T'is Gileads pretious Balme & serues to binde
The wounds & blowes wch here below we finde
Yea happy choyse though thus the World vs treat
Seing that in heauen our reward is great
The Soulder of that name vnworthy is
That trembles att the sight of enimyes
Soe is the Christian wch that title bear's
If he att threats of aduerse destine fear's
But wth a patient calmness lett's receaue
What the Soueraigne hand is pleas'd to giue
[p. 585] The Midle Region or those parts aboue
Are least obscurd nor ther doe Tempests moue
Soe should our soules be raysd boue Passions sphere
Noe Stormes of Tongues Nor Cloudes of enuy feare
In fronts of Batailes we our fortunes Sett
The Ship at Sea wth stormy winds is bett
The Pilot scapt from former gusts noe more
Feare's ship-wrack now then what he did before
The Soulder oft to frequent perills knowne
Neglect's the danger that's soe Comon growne
And soe should we when our Aflictions growe
W^th^ lenghtned Patience learne to beare them too
This Life's a war-fare if sometimes begun
To parly wth our sorrowes t'is soone done
And in th' end when hopes begin to Cease
[p. 586] Proues but a Cessation noe Continu'd Peace
Whilst through cleare skyes the Sun triumphant rides
Vpon a sudden cloudes his splendor hides

Doth health & Pleasure spur our sences on
Soon sickness Comes and all delights are gone
Such is the State of vs vncertaine men
To know in calmes to guide our Vessels then
Is not enough, but t'is when Tempests rise
To steare a Course both Patient, Stout, & Wise
Did our misfortunes soe deuide our share
As some shee would Aflict & others Spare
We might Complaine of her inconstant fitts
Bullets as soon th' Captaine as soulder hitts
The Feauer to the Great a deafe eare hath
[p. 587] As to the meanest both subuerts by death
Soe may the Justice of Impartial fate
For Comfort serue vs in our greatest Strait
Why doe we enuy then aspiringe Men
W^th^ Stormes the Vallyes are less troubled then
The lofty Hills & humble shrubbs belowe
Less danger's in then Oakes that highest growe[1]
See we not how the straitest Popler tree
And spredinge Elme as they vngratfull be
For nurishment) to barreness incline
Whilst prostrate on the ground the Crocked vine
Abundance yeilds or haue we nott seene
From highest plenty men in wants haue beene
How many Kings falne from ther Regall seate
Haue Crack't their Crownes ther Royal Septers breake
[p. 588] Our Wittnesses by cloudes we all may bringe
To shew that splendid honours a vaine thinge
Should they be ta'ne from vs resolue thus much
Ther loss should not be great ther fading's such
Should we aflict ourselues when loss appear's
Our Teares would sooner want then Cause for teares
All you wth heauenly Marks of God indued
Arme to the Fight shew Virtue Fortitude
As Rocks 'gainst wch the raging billowes rore
Keepe firme ther station on the threatned shore
Soe let our Soules be firme & Constant still
Against the threats this World doth make of Ill
Or as a Diamon mongst the dust doth dart
The beauty more in itt's resplendent sparke

[1] Cf. Horace, *Carm.* II 10.

[p. 589] In midst of troubles soe lett vs demeane
As Countinances be pleasant Soules serene
Remember t'is from high Aflictions fall
From Prouidence deuine that gouern's all
Who when he please in turning of an eye
Turn's Wrath to Mercy Sorrows into Joy
T'is he who made the firtile Earth produce
Her anual fruit most meet for humaine vse
He both the Rose & Violets did Cloth
T'is he beauty & th'oders gaue to both
'Twas his Almighty power that did make fall
Att Israels seige the Jereconian Wall
That on's Enimyes ruing he might raise
Trophy on Trophy to inrich his Prayse
[p. 590] Shal we then those his wonders now less prize
Or thinke his Power abat's, or hee less wise
No, hee's as able still Nor shall His want
Victory on Standards Glory on ther front

[p. 590] Life & Death Compared together

Such vulgar thoughts the World doe fill
To thinke Life good Death only ill
Then life ill liued noe euell's worse
Death (dieing well) remoues the Curse
And tis for certaine truth men tell
He ne're dies ill that liueth well
Ill liues doe but ther Ills increase
[p. 591] But dieng well makes Euells Cease
Badd men haite death but not soe much
That itt is Ill, as They are such
Moral Men teache vs in their bookes
That we should dispise death's grime lookes
T'is Comõn sence wch doth inspire
Ther feares of thatt Good men desire
Nor Can we truly death define
By makinge odious what's sublime
Consider't in th' effects & soe itt will
Plead much for death be't Good or Ill
Say itt be Ill yett here's the Good
To greater Ills it giues a period
In life what one good thinge is ther

[p. 592] To keepe our Passions Reguler
The many Ills each day is done
Makes Death less fear'd but once to come
But rather thanke Death that's the Cause
Our Ills are not Īmortal Lawes

[p. 592] Vpon a Fontaine

Seest thou how these waters flowe
How soone againe away itt glides
Soe worldly Glory's but a showe
That neuer long wth vs abides[1]

[p. 593] Vpon the New-built
House att Apleton

Thinke not ô Man that dwells herein
This House's a Stay but as an Inne
W^ch^ for Conuenience fittly stands
In way to one nott made wth hands
But if a time here thou take Rest
Yett thinke Eternity's the Best

[p. 594] Shortness of Life

In Rosy mor'ne I saw Aurora red
But when the Sun his beames had fully spred
She vanisht I saw a Frost then a Dew
T'wixt time soe short as scarce a time I knew
This stranger seemd when in more raised thought
I saw Death Come How soone a life he'ad Caught
Wher in the turninge of an eye he'ad done
Farre Speedier execution then the Sun

---

[1] Pour une Fontaine
Vois tu, passant, couler cette onde
Et s'ecouler incontinent?
Ainsi fuit la gloire du monde
Et rien que Dieu n'est permanent Malherbe.

[p. 595] Epitaph on A V dieng Younge

O what affront was itt to Nature
And sadder Influence of the Skyes
That in a moment clos'd the Eyes
Of such a machless Creature
But askinge what might be the Reason
That Creuel Fate soe out of season
Had Caried her from vs soe farre
This Answer was to me returnd
Least that the Earth should bee burnd
By th' scorching beames of that bright starr

[p. 596] The Lady Caryes
Elogy on my deare Wife

O Fatal fall might not those heapes suffice
This Sum̃er Captiu'd but thou must surprize
The best of Nobels this soe great good Lady
A Vere A Fairfax Honours-Honour, Shee
Did grace her Birth Sex Relate & Degree
& Shee a Non-parell for Piety
Vers't in the Theory of Godliness
The wch she did in Conference express
Its Practick part her life to life did shew
Each way but most excellinge in all vew
Was Faith Submission vnweared pleasantnes
[p. 597] With vniuersal weaknes, Paine Sickness
Many longe lasting Great few euer sence
Soe followed Job in suffringe Patience
But she is now most gloriously exalted
Wher sin & sorrow neuer entred
To Mount Zion heauenly Jerusalem
The City of God to Sperits of Just men
To Church of the first borne to Angels blest
To God to Jesus this Compleats the rest
Her Faith saw this wch made her smile att death
And wth much Joy surrendred vp her breath
Her Body deare her All thats out of Heauen
To Billbrough church as a riche Treasure's giuen
Bilbrough church-yeard daine me a little roome
That after death my graue waite on her Tombe.

[p. 598] To the Lady Cary

Vpon her Verses on my deare Wife

Madam

Could I a Tribute of my thanks express
As you haue done in loue & purer Verse
On my best selfe then I might Justly raise
Your Elogy t'Encomiums of your Prayse
And soe forgett the Subiect that did moue
Me to a thankfulnes as't did you to loue
Ô t'were to great a Crime but pray allow
Wher I fall short but you haue reached to
Makinge that Good wisest of Kings hath said
Th' Liuing's not soe Preyse-worthy then the dead
I thinke the Reason's this itts grounded on
'Cause Mercys are not priz'd till they are gone
[p. 599] O had not hopes surpast my grosser sence
My loss Could not haue had a recompence
Yett such an Influence hath your happy straine
To bring my buried Joy to life againe
Vertue Goodnes Loue things Iñortalize
The better part when as the other dies
True, Soules in Bodyes haue ther being here
But Loues in Soules haue ther ther proper Sphere
Then is true loue Compos'd of Nobler fyers
Then to extinguish when the Life expires
Butt to Conclude Madam me think you 'spire
In humblest Thoughts to raise your Trophys higher
Then Her's you would attend in gelid Mould
W^{ch} for her Friend the lodging seemes too Could
[p. 600] But were itt soe itt my good happ might bee
To lye next Her, To you our Quire is free

[p. 600] On the Fatal day

Jan: 30 1648

Oh lett that Day from time be blotted quitt
And lett beleefe of't in next Age be waued
In deepest silence th' Act Concealed might
Soe that the King-doms Credit might be saued

But if the Power deuine permited this
His Will's the Law & ours must acquiesse

Curæ loquuntur leues
Ingentes stupent

[p. 601] Of Inpartial Fate

Here we all the Same Danger run
By the like Destin's we are ledd
Same Misfortune to the Shepeard Come
May attack as well the Crowned head
Our dayes are Spun vpon that wheele
The meanest Subiect & greatest Kinge
To like end th' Fatal Sisters bringe
The thread when Cutt both same Sisers feele

[f. 604] A Carracter of the Romish
Church by Francisco Petrarca
Laura Can: 106

Fiamma dal ciel su tue treccie pioua

Heauens dire flame sits on thy Curled tresses
O wrech, from scrip & wallet who's become
Both riche & great through those wch thou oppresses
Soe much reioyces thou when euells Come
A nest of Treasons wher mischeifes bredd
Ther hacht in the o're the World is spred

Wine Bed good Belly chere & pleasant dayes
To All, thy whoredoms to the vttmost shews
[p. 605] Thy seruants younge & old the wanton playes
This fire wth bellowes Bel-ze-bub blowes
Such is thy life thou wicked Epicure
As to the Heauens thy stinch is gone vp sure

Fountaine of Greefe & woe wraths harbor too
Temple of Heresy Pitt of Errors deepe
In elter times we held thee Rome but now
Babel the peruerse for wch wee weepe
A shopp of Cousnage prison of Crueltyes
Wher ills mentaind & wher Goodnes dyes

When founded first wast humble Poore & Chast
Thy hornes against thy Founders now thou lifts
[p. 606] O shameles Strumpet wher's thy trust now plast
Is't in th' Adultryes ill gott Goods or Shiffts
Then vnto All great wonder itt will bee
If Christ in th' End powre nott his wrath on thee[1]

[Fiamma dal ciel su le tue trecce piova,
Malvagia, che dal fiume e dalle ghiande,
Per l'altru' impoverir se' ricca e grande;
Poichè di mal oprar tanto ti giova:
Nido di tradimenti, in cui si cova
Quanto mal per lo mondo oggi si spande;
Di vin serva, di letti e di vivande,
In cui lussuria fa l'ultima prova.
Per le camere tue fanciulle e vecchi
Vanno trescando, e Belzebub in mezzo
Co' mantici e col foco e con gli specchi.
Già non fostù nudrita in piume al rezzo,
Ma nuda al vento, e scalza fra li stecchi:
Or vivi sì, ch'a Dio ne venga il lezzo.

Fontana di dolore, albergo d'ira,
Scola d'errori, e tempio d'eresía;
Già Roma, or Babilonia falsa e ria,
Per cui tanto si piagne e si sospira.
O fucina d'inganni, o prigion dira,
Ove 'l ben more, e 'l mal si nutre e cria;
Di vivi Inferno; un gran miracol fia,
Se Cristo teco alfine non s'adira.
Fondata in casta ed umil povertate,
Contra tuoi fondatori alzi le corna,
Putta sfacciata: e dov' hai posto spene?
Negli adulterj tuoi, nelle malnate
Ricchezze tante? Or Constantin non torna;
Ma tolga il mondo triste che 'l sostene.[2]]

[1] See page 245.

[2] These sonnets are not in the MS.

[p. 612] Vpon the Horse wch his Matie
Rode vpon att his Coronation 1660

Hence then Dispaire my hopes why should itt bury
Sence this braue Steed Bredd first was in my Query
Now thus aduanc't wth highest honors loden
Whilst his that bredd him on by most Mens troden
But t'is noe matter Seing tho' hast gott th' Aduance
Then please the Royal Rider wth thy Prance
Soe may thy Fame much rayse thy Prayses higher
Then Chessnut that begott the or Brid-la-dore his Sire

Bridla-dore (Anglicè)
Golden Bridle

[p. 613] Vulgar Proverbs

None to another freind can be
That to himselfe's an enimy

[p. 614] Of sence & Money & of Faith
Where's the Man that too much hath

Betwixt the Bridle & the Spur
Reason often lodgeth her

In th' house of Foes prepose this End
To gett some Woman for thy freind

[p. 615] The Hope of Gaine—Abateth paine

Wouldst thou have all thy troubles cease
Then see & heare & hold thy peace

Lait (doe we say) repents the Ratt
When by the Neck has hold the Catt

His thoughts are good & ever best
That carryes Death wthin his brest

[p. 617] A fatt Earth makes a Horse to labour
But A good Lawyer is an ill Neighbour

Make Night of Night & Day of Day
Soe wth less sorrow live you may

[p. 618] Pardon to Men that evel be
Unto the God's an injury

When Pride on horseback getteth upp
Loss & shame sitts on the Croup

[p. 620] He that would live in healthfulnes
Must dine wth little & supp wth less

[p. 621] As the evening doth the day cōmend
So life is Praysed by the end

[p. 622] Virtue shewes the greater grace
Shining from a bautious face

[p. 624] Att a rounde Table noe Strife is
Who shal be nearest a good Dish

Dry March Wett Aprel May that's both
Brings plenty wher ther is noe sloth

[p. 625] In a fresh gale
Extend thy Saile

[p. 626] We may be sure still inocence
Beares in itselfe its owne defence

[p. 627] To read & yitt to have learn'd nought
Is like the chase wher nothing's caught

[p. 628] Tis good we should the tongue cōmand
Speake litle & more understand
For if from us our words once fall
It is too laite them to recall

Humaine Praise—Is a vaine blaze

[p. 631] Sett on a Seat a Foole e're longe
He'le wagg his Legges or sing a songe

[p. 633] Nature made nothing so sublime
Butt Virtue to the topp will clime

When a whit frost on earth doth lie
Tis a presage then raine is nie

[p. 635] On a womans first Counsel rest
Seldome the Second is the best

Bread Butter & good Cheese
A shield 'gainst death be al these

Pardon give to every one
But to thyselfe alow none.

[p. 637] When Italy is wthout Fish
When France wthout Treason is
In England longe noe war we see
Then wthout Earth the World shall bee.

[p. 638] My contry is in all lands wher
I goe & meet wth true friends ther.

[p. 641]

The teares of France for the
deplorable death of Henry 4
surnamed the Great

Ah is itt then Great Henry soe fam'd
For taming men himselfe by death is tam'd
Whatt eye his glory saw now his sad doome
But must desolue in Teares sigh out his Soule
Soe small a shred of Earth should him intombe
Whos acts deseru'd pocession of the whole

O t'is but fitt for joyes we henceforth mourne
Our songes & mirth into sad plaints we turne
Instead of this great King greefe may raigne here
So thatt in sorrow plung'd our fainting breath
May send our endless sighs to th'highst Sphere
Whilst hopless teares distill vpon the earth

[p. 642] Yis itt is fitt what else can we returne
Butt teares as offrings to his sacred vrne
W^th^ them his Sable Marble tombe bedew
No no such armes too weake sence itt apeares
For vs he of his blood too careless grew
Haue we naught else for him butt a few teares

O could our eyes to fontains we distill
T' Would nott abaite the least part of our ill
We oft shed teares for simple wrongs oft weepe
Too Comon oft for things of lesser prise
Then lett vs die att this great Monarchs feet
His Tombe th' Alter, our selues, the sacrifice

But who can die if Sisters Fate denies
A closure to our half death trickling eyes
Hauing shut vp those of this warrlike Prince
Atropos so proud's of her royal pray
Her Cypriss into laurels will turne, Sence
Of this great Victor she hath gott the day

[p. 643] But sence we are ordain'd to sigh & liue
And after this ther faitall stroke then giue
Liue then complaining this sad shock of Fate
Wher happy days are gone, no ioy appeares
Then mourne & sigh till death our greefe abate
And shew whilst liuing, Life shal wast in teares

[[1] Quoi? faut-il que Henri, ce redouté monarque,
Ce dompteur des humains, soit dompté par la Parque?
Que l'œil qui vit sa gloire ores voye sa fin?
Que le nostre pour lui incessamment dégoutte?
Et que si peu de terre enferme dans son sein
Celui qui méritoit de la posséder toute?

Quoi? faut-il qu'à jamais nos joies soyent esteintes?
Que nos chants et nos ris soyent convertis en plaintes?
Qu'au lieu de nostre roi le deuil règne en ces lieux?
Que la douleur nous poigne et le regret nous serre?
Que sans fin nos sousoirs montent dedans les cieux?
Que sans espoir nos pleurs descendent sur la terre?

Il le faut, on le doit. Et que pouvons-nous rendre
Que des pleurs assidus, à cette auguste cendre?
Arrousons à jamais son marbre triste blanc.
Non, non, plustost quittons ces inutiles armes!
Mais puisqu'il fut pour nous prodigue de son sang,
Serions-nous bien pour lui avares de nos larmes?

Quand bien nos yeux seroyent convertis en fontaines,
Ils ne sauroyent noyer la moindre de nos peines.
On espanche des pleurs pour un simple meschef.
Un devoir trop commun bien souvent peu s'estime.
Il faut doncques mourir aux pieds de nostre chef.
Son tombeau soit l'autel et nos corps la victime

Mais qui pourroit mourir? Les Parques filandières
Desdaignent de toucher à nos moites paupières,
Ayans fermé les yeux du prince des guerriers.
Atropos de sa proye est par trop glorieuse;
Elle peut bien changer ses cyprès en lauriers,
Puisque de ce vainqueur elle est victorieuse.

Puisqu'il nous faut encor et souspirer et vivre,
Puisque la Parque fuit ceux qui la veulent suivre,
Vivons donc en plaignant nostre rigoureux sort,
Nostre bonheur perdu, nostre joye ravie;
Lamentons, souspirons, et jusques à la mort
Tesmoignons qu'en vivant nous pleurons nostre vie.

[1] See page 246. This is not in the MS.

Bewaile bewaile this our great Monarchs fall
Of Judgment perfait humour pleasing all
His equal none a Hart w^th^out all feare
Perfection such t'would but fall short in prayse
Enough to' aue serued a World to' aue admird here
Had nott his equal Justice bound his wayes

Lament lament this Sage & Prudent King
Thatt hight of Bonty, vigelence in him
Thatt hart wch could be mou'd not ouercome
Virtues here rarely found though we inquire
Parts I could sooner much admire then sum̃e
Sence this Achilis a Homer would require

[p. 644] We cañott count the Splendours of his Glorys
Nor number yitt his signal victorys
O no for such a subiect were too great
We aught to prayse what yitt we cannot write
And hold our peace or to good purpose speake
He nothing saith doth not to th' full recite

His famous acts once raisd our drouping heads
His Laurels from the temples was our shades
End of his Combats ended feares wee're in
Him only pris'd dispis'd all other Powers
More gloring to be subiect to this King
Then if we'ad had some other Kings for ours

But now this Glory's clouded wth a staine
And now our joy & Mirth ther leaue hath taine
The Lillys faide as we att this sad Fate
Downe to the growne ther drouping heads doe bowe
Seeming as humble as Compassionate
To crowne his Tombe or else him homage doe

[pp. 645, 646 *are blank*]

Plaignons, pleurons sans fin cet esprit admirable,
Ce jugement parfait, cet' humeur agréable,
Cet hercule sans pair aussi bien que sans peur,
Tant de perfections qu'en loüant on souspire.
Qui pouvoyent asservir le monde à sa valeur,
Si sa rare équité n'eust borné son Empire.

Regrettons, souspirons cette sage prudence,
Cette extrême bonté, cette rare vaillance,
Ce cœur qui se pouvoit fleschir et non dompter.
Vertus de qui la perte est à nous tant amère
Et que je puis plustost admirer que chanter,
Puisqu' à ce grand Achille il faudroit un Homère.

. . . . . [1]

Pourroit-on bien conter le nombre de ses gloires?
Pourroit-on bien nombrer ses insignes victoires?
Non, d'un si grand discours le dessein est trop haut.
On doit louër sans fin ce qu'on ne peut escrire,
Il faut humble se taire ou parler comme il faut,
Et celui ne dit rien qui ne peut assez dire.

. . . . . [1]

Jadis pour ses beaux faits nous eslevions nos testes,
L'ombre de ses lauriers nous gardoit des tempestes,
La fin de ses combats finissoit nostre effroi.
Nous nous prisions tous seuls, nous mesprisions les autres,
Estant plus glorieux d'estre subjects du roi
Que si les autres rois eussent esté les nostres.

Maintenant nostre gloire est à jamais ternie,
Maintenant nostre joye est pour jamais finie;
Les lys sont atterez et nous avecques eux.
Dafné baisse, chétifve, en terre son visage,
Et semble par ce geste, humble autant que piteux,
Ou couronner sa tombe ou bien lui faire hommage.]

[1] Fairfax omits a stanza here.

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 291-414. MARCH, 1910

The English Moral Plays

BY

ELBERT N. S. THOMPSON, Ph. D.
ASSISTANT PROFESSOR OF ENGLISH IN THE STATE UNIVERSITY OF IOWA

PUBLISHED UNDER THE AUSPICES OF
YALE UNIVERSITY

NEW HAVEN, CONNECTICUT
1910

WEIMAR: PRINTED BY R. WAGNER SOHN

V.—The English Moral Plays.

By Elbert N. S. Thompson.

Chapter I.—The Alliance of the Pulpit and the Stage.

The beginnings of the medieval miracle-plays have been very clearly traced to the tropes that were added in the tenth century to the antiphonal portions of the Gregorian service. As yet the origins of the morality plays have not been determined with equal certainty; partial investigations have yielded only tentative conclusions. The old idea, that the moralities developed from the slight allegorical elements of the late miracle-plays, has been convincingly set aside. The influences, too, of the *Psychomachia*, of the popular Dance of Death, and of the allegorical handling of the verse in the Psalms, "Mercy and truth are met together; righteousness and peace have kissed each other," have been made clear, and of late more thoroughly studied. But a careful examination of the contents and the spirit of the English moralities will reveal more concerning their origin and growth, and, the author believes, will eventually justify the conclusion that both branches of the sacred drama were devised by churchmen to supplement and enforce Christian teaching. The miracle-plays, like the carvings on the portals of the Amiens cathedral or the figures on the windows of Chartres, purposed to teach the facts of sacred history; the moral plays, by placing upon the stage personifications of virtues and vices to represent concretely the temptations that man must face and the means of overcoming them, served to reiterate the moral and doctrinal message of the pulpit. One received its first development in connection with the antiphonal elements of the mass; the other was the direct outgrowth of the ensuing homily.

It would be a great mistake to suppose that early Christian worship consisted chiefly of liturgical forms, to the exclusion or subordination of the sermon. The record of Christ's life, the example of the Apostles, and the tradition of the Jewish synagogue, established at once both the duty and the method of oral instruction. The earliest preachers went forth as missionaries to carry the gospel to distant nations. But almost as soon, certainly in the time of the Apostolic Fathers, each community of believers was accustomed to receive religious instruction from its duly appointed leader. Since this parish preaching was the church's readiest means of getting its

doctrinal and ethical teaching before the people, its importance, naturally, was at once recognized. On Sundays and festival days the sermon had its own fixed place, usually following the reading of the Scriptures, in the regular order of worship. Nor was the preaching confined to such occasions. Many of Augustine's homilies attest the fact that at certain seasons of the year he was wont to preach almost daily, sometimes, we are told, five times a week. Moreover, long series of sermons on various books of the Bible, like Augustine's on the Psalms, or Chrysostom's on Romans, were common; for even those leaders on whom the cares of administration bore most heavily did not slight their parochial work. Instant they were both in season and out of season; during the period when the new religion was still subject to persecution, the foundations of Christian homiletics were strongly laid, and when persecution ceased, the pulpit orator became an acknowledged leader of society.[1]

The earliest sermons were very simple, if not quite extemporaneous, expositions of the Scriptural lessons that preceded them, with a few words added of pertinent admonition and exhortation. This combination, however, of explanation and application, which the example of Origen had fully established, proved susceptible of rich development. Gradually the structure and composition of the sermon were given more thought; its appeal under the influence of the powerful Tertullian became more direct and forceful; and its scope, in the fourth century, was broadened by the introduction of doctrinal teaching. In all these respects the sermon grew in power till its high, but perfectly normal, culmination was reached, for the Greek church in the impassioned eloquence of Chrysostom, and for the Latin church in the clear, practical addresses of Augustine, the profoundest theologian of his age. Through all classes of society in Antioch and Constantinople, Chrysostom's denunciation of vice and pleading for righteousness exerted an influence that made him feared and hated by evil-doers, but loved by his people. From his pulpit in the west, Augustine battled against heresy and sin with a power that often left his hearers in tears.

This, the high-water mark of early Christian preaching, was soon to be succeeded by long centuries of decline and impotence.[2] The right to preach was vested in the bishops alone, and although they, when prevented from performing such service by sickness or enforced absence, were allowed to license substitutes,[3] the number of

[1] Dargan, 63–64.

[2] Milman, Bk. 9, chap. 9.

[3] Lecoy de la Marche, 21–26.

preaching churchmen was altogether inadequate to meet the rapidly growing demands. The bishops and monks, moreover, were rendered worldly by the management of their secular affairs, while the parish priests remained too ignorant or too indifferent to guide the people. Consequently, oral instruction from the pulpit, especially in rural districts, was infrequent and poor. Nevertheless, even in the darkest period there were hopeful indications. Charlemagne and the ecclesiastics of his time urged that every priest be empowered, and even forced, to preach.[1] As another means of increasing the common usefulness of the sermon, in the ninth century exhortation in the open air was encouraged.[2] And that even the ignorant clergymen upon whom these new responsibilities were thrust might have sound teaching to offer, collections of homilies were prepared. All this indicates that religious instruction from the pulpit was not forgotten or contemned. Its high traditions would have been kept alive, if in no other way, by the *Pastoral Care* which Gregory prepared for the instruction of the clergy. That much admired treatise insists with special emphasis that the priest should not be a dumb servant of God. He should understand, to be sure, that discretion oftentimes recommends silence; but he should also be alert to seize those occasions that demand fearless speech. With the aim, therefore, of teaching the clergy to speak effectively, yet with moderation, "to exhort by sound doctrine and to convince the gainsayers," the treatise gives explicit directions for the preparation of sermons. Such instruction came with telling effect from Gregory, who himself set so high an example of faithful and intelligent effort in preaching. The *Pastoral Care* was read all over Europe, even being translated into Old English by King Alfred, and given, as far as possible, to every English priest; and it must have been, to all but the most faithless, a constant reminder of the duties and responsibilities of priesthood.

The latent energy of the medieval church, of which these facts give but a faint indication, reawakened to a new period of activity in the twelfth and thirteenth centuries. The higher clergy, frightened by the persuasive oratory of heretical teachers, entered with new zeal upon their labors among men. At the same time, the truer learning and richer spirituality that ripened in the monasteries, impatient of narrow seclusion, filled the monks with a desire to guide and control. The story of Bernard of Clairvaux shows how fruitful monasticism could be. Finally, in the early thirteenth cen-

[1] Hering, 55–58.

[2] Lecoy de la Marche, 226–29.

tury, the preaching friars of the Dominican and Franciscan orders carried to all parts of Europe the teachings of Christianity, and by their example forced all orders of the clergy to render more efficient and unselfish service to their fellow men. Then, as perhaps never before, from a sense of what humanity had lost through its neglect, the Church gave guidance and inspiration to the common people. The Crusades, the cathedrals, the saints' legends, and the sacred plays, bear witness to the moral awakening. The people were ready for instruction, and the priests and friars strove earnestly to teach them.

In accepting this new understanding of their duties to man, the preachers of the time changed radically their methods. They were at once forced to adapt their instruction, as the friars did, to the ill-trained audiences they addressed. In so doing they but followed a course not unknown in actuality, and long sanctioned in theory. The simplicity and directness of Augustine's discourses witness conclusively to the pains he took to reach the people. The necessity for such practical adaptation had been explained in detail by Gregory the Great in the long third part of the *Pastoral Care*. Moreover, in 816 those churchmen who seemed inclined to forget the teaching were reminded by the Council of Aix-la-Chapelle that the same kind of nourishment was not suited to all stomachs.[1] Preachers, therefore, were unquestionably familiar with the principle; and they must soon have learned by experience, as their sermons were interrupted by disorders, or as they saw groups of men leaving their churches, what popular oratory demanded.[2] The first reform, of course, was to substitute for the Latin language, which was always used in addressing the clergy, the speech of the people. Grosseteste at Lincoln and Abbot Samson at Bury St. Edmunds preached, and insisted that others preach, in English.[3] But preachers had also to learn to vary their treatment of a subject to render it suitable to particular occasions. Undoubtedly, the friars showed the greatest readiness in adaptation, carrying it so far in the next century as to lay themselves open to charges of insincerity and fraud. But in general the preachers of the age worked zealously and creditably to impress upon the world the truths that it had forgotten.

In this common movement of reform and expansion the arts of the orator and rhetorician were not overlooked. Honorius of Autun

[1] Lecoy de la Marche, 207–08.
[2] Ibid., 215.
[3] *Speculum Ecclesiae*, 830. Stevenson, 32, 297.

warned the speaker that he should neither gesticulate as though he were throwing his words at the congregation, nor stand with closed or averted eyes; rather he should speak, as the rhetoricians teach, with moderate gestures, and in a carefully studied manner.[1] Owing, however, to the current opinion that less difficulty was experienced in the composition and delivery of sermons than in the gathering of material,[2] homiletic treatises were more often designed to furnish the busy or unfruitful priest with matter suitable for discourse. At the close of his famous collection of sermons, the *Speculum Ecclesiae*, Honorius of Autun expressed the belief that all preachers filled with ardor for heavenly things would find its many homilies on the gospels and on the lives of saints and martyrs an aid in pastoral labor.[3] He had been induced to undertake the work, his preface explains, by his fellow clergymen, who had found the incomparable sacred writings of the Fathers, either because of their antiquity or because of their elevation of thought, ill suited in certain respects to the audiences of their own time. Hence he had gathered in this series of sermons the most vital teaching of Ambrose, Augustine, Jerome, Gregory, and many other noted preachers, adapting the material, by a convenient arrangement according to the order of church festivals, and by a clear and simple style of composition, to the needs of the day. The *Speculum Ecclesiae* was one of the earliest compilations that sought thus to preserve in practical working shape the best thought of the past.

For the student of the allegorical drama, however, the most suggestive example of this type of literature is Alain de Lille's *Summa de Arte Praedicatoria.* The greater part of the work is devoted to expositions in praise of virtues like patience and obedience, and in condemnation of vices such as envy and pride, and to exhortations to prayer, penance, and other religious duties that the church wished to stress. Exactly these same lessons appeared later in the morality plays in dramatic guise, as though the authors had studied to good purpose the pages of the treatise. Alain de Lille's method, though, is still purely expository. After citing at the beginning of each chapter verses from the Bible applicable to the ethical trait under consideration, he enters upon a discussion of its distinctive qualities and effects that is marked by the orderly, systematic

[1] A story of Demosthenes' eloquence in the *Alphabet of Tales* (No. 639), concludes, "a grete parte of Demostenes wantys when it is red, mor þan when it is hard."

[2] Humbert de Romanis, 456.

[3] 1085.

method of the age. He, too, drew freely from the writings of the Fathers. The scope of this extensive treatise on the virtues and vices, the author's keen analysis of man's varied psychic motives and the sensible, forceful doctrine that concludes the chapters, must have done much to vitalize and quicken in the thirteenth century the objective study of the conflicting impulses of the inner life, and thus to prepare the way for the morality plays.

The leaders of the church, however, felt that it was not enough to collect in such treatises the doctrines that preachers were required to expound; they believed that full directions should also be given for the most effective employment of the material. Honorius, accordingly, gave numerous suggestions for those who were to use the sermons of the *Speculum Ecclesiae*. "Let this be the end, if you wish," he notes at one point, "but time remaining, this may be added."[1] Later he marks a possible end for a discourse in case the preacher found that excessive heat or cold, or any other inconvenience, was interfering with the audience's attention.[2] Of other sermons he designates certain portions as useful only on certain specified occasions, or in churches consecrated to particular saints. These hints remain always quite incidental; for the sermons have an independent value that would render them frequently appropriate. Quite different, though, are the sermons in one whole section of the *De Eruditione Praedicatorum*, which were prepared by Humbert expressly to illustrate the mode of adapting discourse to special places and occasions—"ad omne genus negotiorum."[3] One address he frames for a meeting of the higher clergy; another he intends for a service consecrating a graveyard; a third is to welcome returning pilgrims. For every conceivable occasion a formal model suggests precisely the most appropriate theme and its most effective treatment.

Similar specimen discourses in these treatises were intended to help the priests more directly in applying their words to the particular audiences before them. In the latter part of his treatise,[4] for example, Alain states specifically the needs of soldiers, judges, widows, and other types of people, and shows how the preacher should accomodate his thought to them. With the same end in view, Jacques de Vitry prepared seventy-four sermons supposedly directed[5] to specially designated audiences of prelates, secular

[1] 819. [2] 830. [3] Lib. 2, sect. 2.

[4] Chap. 39.

[5] *Sermones Vulgares*, or, *Sermones ad Status*.

canons, crusaders, husbandmen, or tradesmen, as the case might be. Equally full is the section of Humbert's treatise that exemplifies concretely this same sort of adaptation. The sixty-sixth specimen is addressed "to students of medicine." They should be told, Humbert explains, that the liberal arts and the sciences of law and of medicine were devised, each in its own proper sphere, to restore to man in part the perfection of mind and of body and the instinct for right conduct that were lost through Adam's sin. Of the three means, he continues, medicine is the most valuable, for it advances not only health of body, but may also further works of mercy and the attainment of spiritual health. In the pursuit of this high calling, however, all physicians are not capable or faithful. For these, the author indicates what sort of exhortation should be used, recommending especially the general warning that they trust less to their own skill than to prayer. At the close, the theme as usual is plainly stated, and the leading points embraced by it are listed. In this sermon we have a typical specimen of Humbert's method, which, in general, was the method of all who compiled these manuals of practical instruction; for all had in view the end of furnishing the pulpit of the day with matter and modes of treatment that would convey the teaching of the church most directly to all classes of people.

These *sermonnaires*, however, could be but partially successful in effecting this end. That they were widely circulated, the student of medieval literature finds abundantly proved, and that their formal suggestions for adaptation may have guided practical churchmen to some extent, one may readily believe. But they could be really serviceable only on academic occasions when the preacher would find a homogeneous audience, and not in services that the ordinary parish priest or itinerant preacher would conduct. Hence some more popular means of adaptation was needed; doctrine had to be rendered tangible by pointed illustrations. To supply this want, collections of interesting and even humorous stories, commonly called in ecclesiastical literature *exempla*, were made to serve as clergymen's commonplace-books. They are not to be regarded as distinct either in purpose or character from the *sermonnaires* already discussed; for the most famous collection of *exempla* was made up of stories found in Jacques de Vitry's *Sermones ad Status*; they were to supplement the *homilaria* by supplying in greater plenty, and in more compact shape, anecdotes that even inferior preachers could use to rouse the interest, or sharpen the understanding, of their audiences.

The employment of anecdote to illuminate or enforce is as old, presumably, as moral instruction. As the tried handmaid of exposition it has held in even serious literature a place by no means so inconspicuous or unessential as its nature would seem to allow. How effective such narrative may be when it dispenses almost entirely with its didactic foundation, the parables of the New Testament beautifully demonstrate. Hence it is not surprising that the early preachers resorted at least occasionally to its use. In twelve of the forty homilies on the Gospels, Gregory the Great introduced, most often toward the close, apposite stories, while in his dialogues he added many more that were widely circulated.[1] Not, however, till the late twelfth and early thirteenth centuries did this means of exposition gain its wide vogue. Then, as the preaching friars carried the church's teaching to even the commonest men, they learned the efficacy of the illustrative anecdote. Saint Dominic himself resorted to its use;[2] Jacques de Vitry believed that many are moved by examples who are not reached by precept;[3] Alain de Lille advised preachers to introduce them at the end of their discourses, where interest ordinarily flags, to prove their doctrine.[4] Even a little of such encouragement would have sufficed to establish a practice that gratified so thoroughly the passion of the age for all kinds of narrative. The numerous collections of *exempla* prove their success, but possibly give a wrong impression regarding their use; for their compilers only rarely indicate a story's application, as did Stephen of Besançon in adding to one tale the conclusion: "This tale is gude to tell agayns þaim þat er slaw in penance doyng, or at will not lefe syn or it lefe þaim."[5] Notwithstanding the fact that the compilers usually left the responsibility of interpretation with the preacher, they all insisted, as did Pierre de Limoges,[6] that the *exemplum* should have a direct bearing upon the thought of the sermon; for, after all, the anecdote was intended but as a means to a serious end.

In form, the several collections of *exempla* varied considerably. The contents of *The Alphabet of Tales*, like so many others, were arranged alphabetically under topics such as *Abbas*, *Consciencia*, and *Oratio*, with an abundance of cross-references. Stephen of Bourbon grouped his material topically under the seven gifts of the Holy Spirit, connecting his tales by a thin thread of exposition. Other

---

[1] Crane, xviii. [2] Etienne de Bourbon, 12 ff.
[3] Crane, xx. [4] Bozon, xi. [5] *Alphabet of Tales*, No. 30.
[6] Lecoy de la Marche, 299.

compilers proceeded after no methodical plan. So, also, the *exempla* themselves varied, from a cursory statement, in some instances, giving the merest skeleton of plot, to a complete story, in others, told with zest and skill. The stories, too, cover a fairly broad range. Of course, one compiler borrowed freely from another, usually with no acknowledgment, and all are indebted to practically the same ultimate sources—the *Vitae Patrum*, Gregory's *Dialogues*, the *Dialogus Miraculorum*, and the current saints' legends.[1] Even within a single collection there is some repetition. Nevertheless, the collections offer a wide variety of material; history of all shades of authenticity, saints' legends, fable literature and folk-lore, personal experiences—all contribute to the making of what Hawthorne would call these ministerial "note-books."

Neither the compiler nor those he served drew in all probability any clear distinction between the sources from which the stories were derived. They would classify them, rather, according to the nature of the moral taught, and repeat the same story several times if several lessons were suggested.[2] The tale might be a simple example of right living that the preacher would commend. A holy man once saw "by revelacion" the house that was being built in heaven for the shoemaker who worked steadily all the week, and on the Sabbath went to the church to give his savings to the poor.[3] Other equally effective tales were told as warnings. A blasphemer was afflicted by paralysis of his left hand, and, on his remaining obdurate in the sin, by paralysis of the other members of his body.[4] Still others exposed to ridicule the follies of the day. A certain percentage of the *exempla* can be classed neither as encouragement, nor warning, nor satire; for example, the many tricks perpetrated by clever rogues upon the righteous, are told without any hint of disapprobation, the preacher, no doubt, being left to supply that, in case the audience seemed willing to receive it. Such stories, and indeed not such alone, savor strongly of the tavern jest. But the majority hold true to the original didactic intent of the species. To recall lax Christians to religious ceremonies there were at hand the story of the nun who, forgetting to make the sign of the cross before eating, swallowed a devil with a leaf of lettuce[5]; the example of the poor scholar who amused himself during responses by imitating the street cries of Paris venders; and the very different

---

[1] Crane, lxx.

[2] Bonaventura, 245.

[3] *Alphabet of Tales*, No. 293.

[4] Étienne de Bourbon, No. 392.

[5] Jaques de Vitry.

example of the woman who went from town to town to hear the itinerant preacher, and whom the Lord miraculously fed by a hare sent from heaven.[1] There were stories in abundance on temptation, on good manners and bad habits, on the power of the Virgin, and on moral virtues. Some stories sought even to enforce doctrine, by showing that the active life is not to be altogether despised, or that the excommunicated person is abhorrent even to the lower animals.[2] Occasionally the stories end with a specific statement of the moral; one on anger, for example, in the *Alphabet of Tales*, closes with the words, "for whar þer is labur & felashup commonlie þer is paciens & goddis helpe."[3] Usually, however, in the *exemplum* proper, as distinguished from the moralized tale, the enforcement is left to the preacher, who would see the obvious purport of the tale—whether encouragement, warning, or ridicule—and use it accordingly.

Here, though, lurked the danger. Insist as they might that the *exemplum* must always have a didactic value, the higher clergy could not prevent its misuse by their irresponsible brethren. The line of demarcation between instruction and amusement, propriety and indecency, was often lost sight of by preachers who were above all else anxious to please. Such speakers developed the story at the expense of the sermon, and did not scruple to use ribald tales and scurrilous jests. Without exaggeration Dante could protest[4]:

> Now men go forth with jests and drolleries
> To preach, and if but well the people laugh,
> The hood puffs out, and nothing more is asked.

The abuse inevitably called forth from ecclesiastical councils restrictive legislation; yet, since the proper use of *exempla* was not forbidden, their improper use could not be prevented. A more salutary remedy was found in collections of sacred stories, which were devised to offer all the attractions of the secular collections, with none of their objectionable features. The *Biblia Pauperum*, or the *Virtutum Vitiorumque Exempla*, long attributed to Bonaventura, was intended to supply preachers who had few books or little leisure with suitable illustrative matter from the Old and New Testaments. The compiler admitted the efficacy of anecdote only

[1] Étienne de Bourbon, Nos. 213, 77, 78.
[2] Étienne de Bourbon, Pt. 5, and Bozon's collection.
[3] *Alphabet of Tales*, No. 404.
[4] Crane, lxviii–lxix. *Par.* 29. 115–17.

when kept in close subjection to "sacra verba," and argued that in the Scriptures, the sole repository of absolute truth, must be found the preacher's best help.[1] Hence he gathered many Bible stories, outlining them very briefly and grouping them under such topical headings as "Concerning Idolatry," "Concerning Blasphemy against God," and "Concerning Good Angels." This treatise, and others like it, were prepared to check the resort to objectionable narrative in the pulpit. They plainly testify to two facts: that the *exempla* had found universal favor with the masses, and that the preachers regarded them as too useful to be wisely discarded.

The determination to carry the teachings of the church directly to all classes of men and women in the most effective and even most interesting way, a determination that forced the clergy to make the sermon, both in matter and form, something other than a religious treatise, led directly to the recognition of the drama as a legitimate and useful aid. Already the church had grown accustomed to compose and enact at the altar for the instruction of the people the most important incidents of sacred history, very simply at first, but soon with ever increasing elaboration and display. Certain uncompromising theologians condemned the miracle-plays, and tried to suppress them; but their efforts at reform availed little. The people were fond of sacred representations, and we may well believe that the preacher whose aim was really evangelistic appreciated too thoroughly their didactic value to abandon them willingly. Moreover, even those who felt the sacrilege of the miracle-plays could not offer that objection against the dramatic portrayal of virtue and vice; they might even regard this as a safe check upon the other. There was ample precedent, therefore, for utilizing the drama as a subsidiary means of moral instruction. Of course, had ecclesiastical affairs been under the guidance of merely philosophical theologians, the idea of placing upon the stage personifications of moral qualities to illustrate the wages of sin and the power of holiness, would have seemed both artistically and psychologically incongruous. But churchmen had dramatic impulses that ruled their manner of expression and their modes of thought. The employment, therefore, of the moral play to enforce the teachings of the pulpit was in strict accordance with the spirit of the age.

Instinctively medieval churchmen, especially the monks, felt themselves so near to God that they conceived of sacred things in a

[1] *Praefatio*, 244–45.

dramatic spirit. The preacher often unconsciously threw his discourse into the present tense, speaking as though Christ and the Apostles were still living and teaching upon earth. Augustine, for example, began a homily with the words, "I am reminded to speak to you, beloved, on that exhortation which the Lord hath just now uttered out of the gospel."[1] The one to feel this relationship most intimately was probably Saint Bernard, who customarily spoke of the saints as his contemporaries. In retelling the story of the Annunciation as given in the Gospel of Luke, he imagines himself standing with the angel before Mary, and addresses her directly; in the sermon on the Purification, he discusses with her the need for her compliance with the law.[2] The freedom betokens, it seems, not rhetorical artifice, but the closest sympathy with sacred story.

It was inevitable that preachers who read the Scriptures with this personal intimacy should reproduce in direct discourse many of the effective dialogues found in the Bible. Bede, in the simplest way, without thought of narrative effect, would read the verses one by one, and give each full explanation. Thus, for example, Gabriel's speeches to Mary at the Annunciation lose all their dramatic value in the accompanying discussion.[3] Gradually, though, a more dramatic style came to prevail. Ælfric and the Blickling homilist of the tenth century accorded the Biblical dialogue greater prominence, keeping the speeches more closely together by restricting the interpolated expository matter. In these homilies, and in later sermons of the twelfth and thirteenth centuries, the impression of rapid, realistic dialogue is thereby gained. Wherever the Scriptural passage that he was handling made it possible, as was the case throughout the sermons on the Song of Songs, Bernard conducted the dialogue in this dramatic style, interspersing between the speeches found in the text his own comments, but connecting by phrases of his own the dissevered parts. In such simple Scriptural dialogue, the Annunciation scene, the miracles, the stories of the saints, and other vivid episodes from sacred history, were transplanted to the literature of these four centuries without emotional and spiritual loss.

If the living presence of Gospel narrative in the hearts of the higher clergy thus inspired the frequent use of simple dialogue in the pulpit, so on their part the *exempla* that we have discussed prompted the inferior preachers, and, in their less serious moods,

[1] Sermon 3, p. 48.
[2] *Œuvres Complètes*, 3. 355; *Ibid.*, 327.
[3] 5. 360–68.

the greater ones as well, to the same course. The telling of these stories with brevity and point practically necessitated dialogue, as one can see by examining the *exempla* of the *Speculum Ecclesiae*, in which the collection's most conspicuous instances of direct quotation are found. Honorius tells the story, later incorporated into the *Alphabet of Tales*, of the miserly tax-gatherer who was saved from hell by his one act of unmeaning charity, and who lived to see Christ in heaven wearing the cloak he had given an unworthy beggar.[1] He cites the familiar examples, also, of the harlot converted by a priest, and of the dead man who returned to divide his property wisely and to tell what he had seen in the other world.[2] These stories are very unobtrusively introduced by Honorius for the *exemplum* had not then attained its full popularity; yet he allows the characters to speak for themselves. In another twelfth-century compilation, the story that Jacques de Vitry told of the devil's giving eight of his daughters in marriage to representatives of eight different classes of society, but leaving the ninth, Lust, to enjoy the freedom she desired, was more fully developed.[3] So it was, as one would expect, that these illustrative narratives proved readily adaptable to dramatic rendering in the pulpit.

Not, however, in these anecdotal excrescences, but rather in sermons on the most serious and exalted themes, did dialogue find its fullest opportunity. After learning to rehearse the simple dialogue contained in the Scriptural lesson of the day, preachers took soon the next obvious step, and simulated as real a more extended dialogue that might plausibly have been carried on by Bible characters. To add to the reality of the words, some brief description of the scene could be added, or more effectively developed, and the preacher would then be virtually reciting, as men were supposed during the Middle Ages to have read in public the comedies of Plautus and Terence, a religious play. Professor Cook has called attention to three homilies of Grecian churchmen composed in this dramatic form, and to a fourth attributed to Augustine—all on the Annunciation and Incarnation.[4] So great was the dramatic impulse of the age that preachers of the Latin Church, as early even as the

[1] Nos. 316, 297.

[2] Jacques de Vitry, No. 257; *Alphabet of Tales*; *Patr. Lat.*, 172. 889, 892–94, 897–98, 881–82.

[3] Printed by Bourgain, 220–23. The same story is in Jubinal, *Nouveau Recueil*, 1. 283.

[4] *Journal of Germanic Philology*, 4. 421–51.

tenth century, used without scruple the artifice of dialogue for the very framework of their most important sermons.[1]

The Blickling homilist, in his sermon on The Story of Peter and Paul, retained the abundance of dialogue that he found in his apocryphal source, giving it, however, a prominence that determined the nature of the whole discourse.[2] After a short introduction, he states the theme of his drama—the contention of the two Apostles with Simon Magus when they were brought before Nero to face the sorcerer's accusations. The preliminary situation is then explained by the author. But immediately, as the accused are brought before the emperor, Simon in person prefers his charges. "Hear me, worshipful emperor; I am the Son of God, who came down from heaven, but I have up to this time suffered great injury from Peter." Thereafter the story is carried on largely by the characters themselves. Nero asks for explanations; the accused and the accuser recite facts and submit charges; the tests that are to establish the false pretensions of one party or the other are proposed and carried through, till finally Peter's prayer dashes the presumptuous magician to death. Some of the speeches are long and devoid of action; but there is a good deal, also, of brisk, natural conversation. "Then said Simon the sorcerer, 'These are the disciples of the Nazarene Saviour.' . . . Nero said, 'Who is the Nazarene?' Simon replied, 'There is a city in the land of Judea, called Nazareth, from whence came their teacher.' Then said Nero, 'God instructeth and loveth every man; why persecutest thou these men?' Simon said, 'These are the persons who frustrate all my works, so that folk should not believe in me.' Then said Nero, 'Why were ye two or your kin so faithless?' Then said Peter to the sorcerer, 'Thou wast able to teach thy false crafts to all other persons; but God through me convicted them of falsehood . . . thou couldest not overcome me.'[3]" The sermon, as one sees, is virtually a dramatic narrative.

Equally notable for its dramatic form and spirit is the sermon on the Assumption of the Virgin in these same tenth-century homilies.[4] Here the progress of the dialogue is just as effective, and the suggestion of action even more clear and dramatic. The angel brings Mary a palm sprig; Mary dresses herself in preparation for the end; the Apostles are conveyed miraculously to the scene; the procession

[1] Bourgain, 211–12, regards the practice as peculiar to the twelfth century.

[2] *Apocryphal Gospels, Acts, and Revelations*, 256–78.

[3] 174. [4] 136–59.

is formed; the Jew who would dishonor the bier is smitten from heaven. These are some of the plainly suggested dramatic situations that transform the sermon into a little drama.[1]

In exactly the same spirit, Bernard preached on the text, "Filiæ Jerusalem, nuntiate dilecto quia amore langueo."[2] After first explaining the different methods of treating such a subject, the preacher sketches for his hearers the scene, showing Mary on her sick-bed with the angels about her. He then rehearses the conversation that might have passed between them. The angels ask Mary why she has not been seen recently on Calvary or the Mount of Olives, or at the tomb. She gives at first a brief reply in the words of the text, "I am languishing." "Of what do you languish?" the angels inquire. "How can sickness trouble the body in which the salvation of the world has rested?" Thereupon Mary, in longer, slower speech, tells them that she is dying not of grief or pain, but for love of her Son, who, she knows, will not forget her. Thereupon the angels, returning to heaven, report to Christ what they have learned. As the scene thus changes to heaven, with one of his customary transitions, "Quid putamus Jesum nisi tale aliquid locutum?" the preacher returns again to dialogue, as Jesus supposedly assures the angels that he, whose gospel is love, will not forsake his own. Perhaps this brief outline will indicate how dramatic in spirit the sermon is; it contains a definite suggestion of the scene, brisk dialogue, and an effective close.

The fact is too little noted in the study of the origins of the sacred drama that at the time tropes were bringing the dramatic portrayal of sacred history to the altar, sermons were being delivered on the same themes and in exactly the same spirit.[3] But these narrative sermons in dialogue were not restricted to Bible story; one significant example of an original dramatic situation is found in Bernard's address on Saint Clement.[4] The speaker reminds his hearers that the saint was ready to sacrifice his worldly position

[1] The source of this sermon is the apocryphal *De Transitu Mariae*.

[2] *Cantic.* 5. 8. *Patr. Lat.*, 185. 190–93. Bourgain, 211, attributes the sermon to Guerrie d'Igni. Bourgain, 373–83, prints a sermon by Anselm on the Resurrection.

[3] The sermon, once attributed to Augustine, in which the prophets, one after another, rehearse on the request of the preacher their testimony of the Christ to come, was read as a part of the Christmas service. It was, then, not a sermon in the sense in which we are using the word. See Sepet, *Les Prophètes du Christ*, 3. 10.

[4] *Œuvres Complètes*, 3. 468–70.

and disregard his mental attainments, to win the love of God. At this point Bernard fancies that Satan is before him, muttering between his teeth as of old, "All that a man hath will he give for his life," and accordingly the preacher turns to show Satan that Clement had offered even his life for Christ.[1] Bernard almost feels that the saint had actually despised his body, until Clement assures him in the words of Paul, "no man ever yet hated his own flesh."[2] But some one of the auditors is here supposed to object that he, too, could show the same fortitude were the time of persecution not passed, and thus is introduced Bernard's homily on steadfastness in minor trials. In this original sermon, Bernard has obliterated all distinctions of space and time to bring together a number of characters, the devil and the saint, Bernard himself and a member of his congregation, in a conversation purely didactic in character. Here, then, is a very significant example of the homiletic rendering of little dramas that bear a strong resemblance to the moral plays.

But the clergy found not only its medium of communication in the widespread dramatic impulse of the age; they found in it as well their expository method; for the use of allegory as a means of embodying moral principle, which is the distinctive feature of the moralities, sprang directly from the inability of the mind to conceive sheer abstractions, and the consequent tendency to represent them as living beings. The essays of the Alexandrian philosopher Philo, dealing with subjects like Justice and Sobriety, undoubtedly gave an incentive to psychic study. But the poets imbued these qualities with human life. One of the popular fables of Phaedrus relates the experiences of two travelers, Truth and Falsehood.[3] In the *Metamorphoses* of Apuleius, likewise, Terror and Fear appear as servants of Minerva at the judgment of Paris, just as in the story of Cupid and Psyche such characters as Sobriety and Solicitude take their parts. The poet Claudian, of the fourth century, was especially fond of such personifications, introducing freely virtues and vices as human beings.[4] Such a method of personification immediately recommended itself to Christian writers. Poets and the authors of religious and educational treatises were soon using allegory as their means of exposition. The preachers, therefore, who would place their teaching on the stage, found at hand a popular, and, on the whole, an effective, method of vivifying the abstract principles of their faith.

---

[1] Job 2. 4.
[2] Ephesians 5. 29.
[3] Hervieux, 2. 139–40.
[4] See Ebert, 1. 287–88.

Two religious treatises of the second century may be taken to illustrate how quickly the allegorical method was absorbed into Christian literature. The more important, perhaps, is *The Pastor of Hermas*, a strange piece of apocalyptic literature which for three centuries enjoyed a popularity that seemed destined to fulfil the hopes of its unknown author, who wrote in order that erring Christians might be reclaimed. In the first vision the dreamer sees, among other things, seven women, who are introduced by the expositor as the seven Christian virtues, Faith, Self-Restraint, Simplicity, Innocence, Moderation, Knowledge, and Love. Some of these same personifications appear again, with others, in a later vision, where they seek to build on the solid rock, the Son of God, the high tower that typifies the Church. Other women, representing vices, comely in form, but dressed in black, and with disheveled hair, carry away the imperfect stones, while the virtues stand guard in the completed structure.[1] The apocalyptic element of *The Pastor of Hermas* predominates over the allegorical; but the interpretation of the visions gives a suggestion of material abundant enough to form an extensive and vigorous piece of allegorical narrative.

The same device of depicting the Christian virtues as young women was employed by Tertullian. Among the several treatises that he wrote on such abstract themes as modesty, idolatry, and penitence, that on patience, *De Patientia*, is the most significant. Towards its close the author draws the likeness of his subject. "Her countenance is tranquil and peaceful; her brow serene, contracted by no wrinkle of sadness or of anger; her eyebrows evenly relaxed in gladsome wise, with eyes downcast in humility, not in unhappiness; . . . her clothing, moreover, about her bosom white and well fitted to her person, as being neither inflated nor disturbed."[2] This suggests no complete allegory, as the *Pastor of Hermas* does; but, elaborating pictorially one allegorical conception, is of equal importance. Both works forecast plainly what was to come.

The tendency toward allegory found in these two treatises soon became dominant in Christian literature. The Christian allegorist devised many forms for the expression of his imaginings. Virtues and vices appeared as living beings, and the progress of the soul in righteousness or unrighteousness was unfolded as a material history, marked by crises, sudden reversals of fortune, and eventual defeat or victory. In the telling of this story, certain episodes

[1] Part 3, Similitude 9, especially chaps. 9 and 15.

[2] Cf. Philosophy in Boethius.

such as the conflict between the virtues and the vices, the debate between the body and the soul, the coming of Death to summon man, and even the Judgment scene itself, were widely accepted. Most of the didactic poems and treatises that handle these themes seem to-day inexcusably long and tedious; many were strictly academic in purpose. But the allegory that they contained could be used just as effectively in plain sermons and popular religious manuals, where it proved itself an indispensable aid in the transmission of religious truth.

In their allegorical sermons churchmen used dialogue just as naturally as in their recital of historical or biographical fact, and thus recited dramatic scenes that were really moral plays. In a brief bit of dialogue in one of the *Blickling Homilies*, "The End of the World is Near," a man who stands at the grave of a lifelong friend is informed by the bones that nothing remains but "a portion of dust, and the relict of worms," and is urged to incline his heart to good counsel and prayer.[1] Still more significant are Hugo of Saint Victor's and Bernard's sermons on the intercession of Mercy and Peace for the sinner whom Justice and Truth would condemn, for these discourses, which will be shortly outlined, place fictitious words in the mouths of these allegorical characters—the essence of the moral plays.[2]

A very similar moral allegory was carried by Peter of Blois to a conclusion that marks his sermon still more emphatically as the forerunner of the English moralities.[3] It is based on the verses, "Who will rise up for me against the evil doers? or who will stand up for me against the workers of iniquity? Unless the Lord had been my help, my soul had almost dwelt in silence." In the spirit of these words the preacher loses at once his own identity. "What can I, poor man, do," he exclaims, "unless God aid me against the evil doers!"[4] His little drama halts a while to permit the discussion of three books, the Book of the Way, the Book of Conscience, and the Book of Life, which man will see at Doomsday. But the preacher shortly returns to picture the scene at God's judg-

[1] 112.

[2] S. Victor, *Patr. Lat.*, 172. 621–25, and Bernard, *Œuvres Complètes*, 3. 340–48. See below, chap. 5. In one of the most interesting *exempla* of the *Alphabet of Tales* (No. 496) Righteousness, Truth, Peace, and Mercy figure as characters. One of Bozon's *exempla* (No. 3) introduces the same type of character.

[3] Sermo ad Populum, *Patr. Lat.*, 207. 750–75.

[4] Ps. 94. 16–17.

ment-seat, whither man has been brought to answer the accusations of his adversary, Satan. The charges that man has been guilty of infidelity to the sacraments, of treason, and of theft, the accuser supports with a fulness of evidence and a force that would characterize a trained advocate. The prisoner can respond but feebly when called upon for his defense, and since Conscience, in spite of the prisoner's questioning the legality of a woman's testimony, confirms the charges, the case for him seems lost. But, opportunely, the three daughters of the judge, Faith, Hope, and Charity, intercede for him under the leadership of Faith, whom the preacher introduces in the words of Prudentius, "Prima petit campum sub sorte duelli Pugnatura fides."[1] The controversy, though, that she enters, is not the open conflict of the *Psychomachia*. Satan asks Faith why she is soiling her purity by defending the sinner, and offers the specious argument that, since faith without works is dead, and since a man who sins in expectation of pardon is accursed, the prisoner deserves none of her sympathy. But Faith, who is too thoroughly cognizant of his wiles to trust his plea, can justify her actions. Their part as intercessors, she shows, is in strict accord with justice and divine will, while his efforts to thwart their purpose is both a usurpation and perversion of divine law. Turning then to the sinner, she depicts the punishment that awaits him if he dies unrepentent, and thus leads him to profess his belief in the Trinity and the doctrines of the church as expounded by the Fathers and the preachers, and to promise amendment. Such doctrinal instruction as a prelude to forgiveness was common in the moralities, and this sermon seems in this respect full of significance. The Virgin and the court then join the sisters in their prayers for mercy, and God grants the accused full pardon.

Is it assuming too much to regard these sermons in dialogue on allegorical themes as the forerunners of the morality plays? If ministers in the pulpits were accustomed to present such dramatic situations, the next step would be to enact them professedly as dramas. Already dramatically conceived incidents from sacred story were being presented by churchmen at the altar; it was therefore no great innovation for churchmen to act, or encourage others to act, the deeds that these allegorical sermons in the pulpit outlined. Of course, these themes, not being based on the sacred text itself, would find no place in the mass. But if a churchman like Stephen of Bourbon could justify a telling story in the pulpit as a "sermo

[1] *Psychomachia*, ll. 21–22.

corporeus" that "passed readily from the sense to the imagination, and from the imagination to the memory,"[1] preachers would recognize the same efficacy in the allegorical play, and willingly give it their support. Thus it happened that the precepts of the pulpit became the stock property of the theater; that the sermon supplied the matter and the spirit of the moral play.

Chapter II.—The Most Typical Moral Play.

The moral teaching that the church saw fit to intrust to the stage, and the means most commonly used to embody such intractable material in dramatic form, are best illustrated by the earliest of the extant English moralities, *The Castle of Perseverance*. This long play of almost four thousand lines, truly a "sermo corporeus," depicts the ceaseless struggle between sin and holiness for the soul of the hero, Mankind. Although he at the start represents himself as a naked infant born but the night before to the "woo & wepynge" of the world, the play cannot strictly be said to begin the story with the follies of his youth, as some moral plays did, for immaturity either in thought or act is nowhere noticeable.

Since, however, the matter of the *Castle of Perseverance* is so full and varied, it may fairly be called a "full-scope" morality. It may also be called the *model* play. The spirit that pervades it responds exactly to the spirit of the medieval church; the doctrine taught is in strict accord with ecclesiastical teaching; and the experiences through which the personified abstractions pass represent the favorite episodes of medieval allegory. In all these respects, *The Castle of Perseverance* is the most typical specimen of the morality play.

At the beginning, Mankind is brought face to face with the great problem of life. His reference to his weakness and inexperience, it seems, has no dramatic significance, and, in view of the purpose of the play, offers no real inconsistency. The churchly author would simply have us understand that even the infant is subject to temptation, and morally responsible for his acts. Consequently, two angels accompany Mankind, Good Angel sent by Christ to guide the boy, and Bad Angel delegated by Satan to tempt him; for

[1] Étienne de Bourbon, 5, Prologue.

swyche to, hath euery man on lyue,
to rewlyn hym & hys wyttis fyue.[1] (310–11)

The responsibility is fully realised by Mankind, who prays that he may

folwe, be strete & stalle,
þe aungyl þat cam fro heuene trone. (316–17)

But the tempter is insistent, and the sway of the evil powers, the World, the Flesh, and the Devil, who are seated on their thrones upon the stage, very near. The misguided soul, accordingly, is easily brought to forsake his true guide in order to seek in the world the base pleasures that Wealth and its privileges can give.

Disregarding, then, the warnings of Good Angel,

a! nay! man! for Cristis blod,
cum a-gayn be strete & style!
þe Werld is wyckyd, & ful wod,
& þou schalt leuyn but a whyle.
What coueytyst þou to wynne?
man! þynke on þyn endynge day
Whanne þou schalt be closyd vnder clay!, (403–09)

and heeding the counsel of Bad Angel,

With þe Werld þou mayst be bold
tyl þou be sexty wynter hold.
wanne þi nosë waxit cold,
þanne mayst þou drawe to goode, (418–21)

Mankind chooses his own course:

I vow to God, & so I may
Make mery a ful gret throwe;
I may leuyn many a day;
I am but ȝongë, as I trowe,
for to do þat I schulde. (422–26)

He is first introduced by Bad Angel to World and his attendants, Folly and Pride, who promise him for his submission the carnal

[1] In one of his sermons Jacques de Vitry told this story of Bonus Angelus. A man who has committed a heinous crime is led to confess to the Devil who has disguised himself as a priest. The Devil bids the man never mention the crime again, and when the man dies he claims his soul on the ground that his sin has never been confessed to a proper priest. Bonus Angelus appears just in time to insist that the man's good intentions should be sufficient to save him. *Exempla*, No. 303.

pleasures he desires. Backbiter volunteers to teach him the way to the Seven Deadly Sins, and Covetousness inflames him with greed. One after the other the Seven Deadly Sins instil their poisonous teachings into his heart. Pride, for example, urges him to despise his fellows, and, lest they take him for a goose, to jag his clothing, wear long-toed shoes, and in all other respects to

> put holy þyn hert in pride. (1073)

Sloth, in his turn, advises him to forget his religious duties for ease.

> whanne þe messë-bellë goth,
> lye stylle, man, & take non hede!
> lappe þyne hed þanne in a cloth,
> & take a swet, I þee rede;
> Chyrche-goynge þou forsake. (1215–19)

Led by such invidious counsel, Mankind is apparently lost, and the sorrowful Good Angel, who has witnessed what he could not prevent, foretells his fate:

> alas! Mankynde
> is bobbyt & blent as þe blynde!
> In feyth, I fynde,
> to Crist he can nowt be kynde.
> alas! Mankynne
> is soylyd & saggyd in synne!
> he wyl not blynne,
> tyl body & sowle parte a-twynne. (1289–96)

Grieving thus over Mankind's sorry predicament, Good Angel is discovered by his friend Shrift, to whom he explains the cause of his sorrow. Shrift, however, sees a chance of a quick amendment if only Mankind can be brought to confess his sins. Accordingly they seek him, and, with the aid of Penance, readily bring him to see his wrong-doing and ask for forgiveness:

> I haue synnyd many a þrowe
> In þe dedly synnys seuene,
> boþe in home & halle. . . .
> þe x comaundementis, brokyn I haue;
> & my fyue wyttis, spent hem a-mys;
> I was þanne wood, & gan to raue:
> mercy, God! for-geue me þys! . . .
> now, seynt Saueour! ȝe me saue,
> & brynge me to ȝour boure of blys!

I can not allë say;
but to þe erthe I knele a-down,
boþe with bede & orisoun,
& aske myn absolucioun. (1477–95)

Shrift then has power to absolve Mankind:

I þee a-soyle, with myldë mod,
of al þat þou hast ben ful madde,
In forsakynge of þyn aungyl good,
& þi fowle flesche þat þou hast fadde,
þe werld, þe deuyl þat is so woode,
& folwyd þyne aungyl þat is so badde.
to Jhesu Crist þat deyed on rode,
I restore þee a-geyn ful sadde;
noli peccare!
& all þe goode dedys þat þou haste don,
& all þi tribulacyon,
stonde þee in remyssion:
posius noli viciare. (1523–35)

Thus the conflict between man's good and evil inclinations was represented concretely on the stage. The subjective forces that in reality belong to man himself in the most personal sense were transformed by the poet into visible, external forces operating upon man as they obeyed, on the one hand, the call of God, or, on the other, the interests of the World and the Flesh. Such a transformation, although not congruous to the truest understanding of sin, was essential to the allegorical method of exposition, and was therefore widespread in the didactic literature of the Middle Ages. Many abstract treatises, to be sure, were written in which the analysis and synthesis of ethical traits, such as the "seven gifts of the Holy Spirit," were carried to the last degree. This was the method of Thomas Aquinas, whose *Summa Theologica* remains the greatest monument of this sort of composition. But the more vital mode of treating such themes was the allegorical. The motives and impulses of man's own heart were taken from him, and, clothed in flesh and blood, given him again for companions.

This extended moral play, however, does not stop, as many did, with this one general representation of the struggle that rages in man's heart. The story of Mankind's life is carried further through a series of allegorical episodes which had been early popular in Christian didactic poetry. The first is a more specific embodiment of the conflict between virtue and vice. Mankind, after gaining

absolution, seeks refuge in the Castle of Perseverance, where he hopes to escape his tempters. But the vices rally about the standard of Belial, and advance in a body to assault the castle. Of the actual engagement that follows only the most meager description is given by the churchly author. Pride confesses himself beaten by Meekness:

> I weyle & wepe, with wondys wete;
> I am betyn in þe hed.
> my prowde pride a-doun is dreuyn,
> so scharpely Mekenes hath me schreuyn,
> þat I may no lenger leuyn;
> my lyf is me be-reuyd. (2203–08)

Envy, in turn, reports herself repulsed by the roses that Charity has thrown from the walls. This paucity of narrative detail, however, is amply made up for by an extreme fulness of preaching; the battle, in short, was the theologian's. Before the assault is attempted, the seven virtues fortify Mankind with effective little homilies. Industry urges him:

> In besynesse, man, loke þou be,
> with worþi werkis goode & þykke!
> to slawthë, if þou castë þee,
> it schal þee drawe to þowtis wyckke.
> Osiositas parit omne malum;
> it puttyth a man to pouerte,
> & pullyth hym to peynys prycke,
> Do sum-what al-wey for loue of me,
> þou þou schuldyst but thwyte a stycke;
> with bedys, sum tyme þee blys!
> Sum tyme rede, & sum tyme wryte,
> & sum tyme pleye at þi delyte:
> þe deuyl þee waytyth with dyspyte
> whanne þou art in Idylnesse. (1644–56)

Meanwhile, the vices are considering what means each one, according to his nature, has of regaining their escaped prisoner:

> help we, Mankynde fro ȝone castel to keuere!
> helpe! we mon hym wynne.
> schete we all at a schote,
> with gere þat we cunne best note,
> to chache Mankynde fro ȝene cote
> In-to dedly synne. (1955–60)

Even when the champions of good and evil have actually met in pairs, Pride with Meekness, Wrath with Patience, Envy with Charity, and so on, the sermon obscures the narrative. In response to Pride's threats, Meekness comments on the cause of Lucifer's fall and on the humility of Christ, garnishing her discourse with the Psalmist's reflections on the fate of the proud. So, too, Patience, in utter disregard of the "styffe stonys" with which Wrath pelts her, draws a moral from Christ's example:

> whanne he stod meker þanne a chylde,
> & lete boyes hym betyn & bynde:
> . . . . . .
> & ȝyt, to deyen he was glad,
> us, pacyens to techyn & lerne. (2128–38)

And against Envy's threat,

> let Mankynde cum to us doun,
> or I schal schetyn to þis castel town
> a ful fowle defamacyon, (2157–59)

Charity replies:

> þou þou speke wycke & falsë fame,
> þe wers schal I neuere do my dede.
> who-so peyryth falsly a-noþer mans name,
> Cristys curs he schal haue to mede:
> ve homini illi per quem scandalum venit.
> (Matt. 18. 7.)
> who-so wyl not hys tunge tame,—
> take it sothë, as mes crede,—
> wo, wo, to hym, & mekyl schame!
> In holy wrytte þis I rede;
> for euere þou art a schrewe. (2161–69)

Thus the battle becomes ecclesiastic exposition, with no headway in action. The second assault would have failed as the first did, had not the enticements of Covetise finally drawn Mankind, in spite of Generosity's earnest pleadings, again to forsake his friends for illicit pleasures with his carnal enemies.

Mankind's second experience in the toils of sin needs no analysis. Since he has been endowed by God with freedom of the will, he must be left, the virtues declare, to suffer the punishment of his ill-advised choice. The time, however, is short in which he can enjoy the wealth that Covetise gives him; for "drery Dethe" soon appears to call him to judgment. The bringing of this summons

to the various classes of society was a favorite subject for the mural painters and the didactic poets of all Europe. Hence the messenger who at this point introduces himself to Mankind was a familiar figure to the audience, and his message but repeated the oft-heard warning of the clergy:

drery is my deth-drawth;
a-geyns me may no man stonde;
I durke, & down I brynge to nowth,
lordys & ladys in euery londe.
whom-so I haue a lessun tawth,
onethys sythen schal he mowe stonde;
In my carful clothys he schal be cawth,
rychë, porë, fre & bonde:
whanne I come, þei goo no more.
where-so I wende in any lede,
euery man of me hat drede;
lette I wyl, for no mede,
to smytë sadde & sore. (2792–2804)

Just as familiar were the reproaches that Mankind's soul at this crisis heaps upon him:

body! þou dedyst brew a byttyr bale,
to þi lustys whanne gannyst loute;
þi sely sowle schal ben a-kale;
I beye þi dedys with rewly rowte;
& al it is for gyle.
euere þou hast be coueytows,
falsly to getyn londe & hows;
to me þou hast brokyn a byttyr jows;
so welaway þe whyle! (3013–21)

Again the play might have closed with this version of the Dance of Death, and this suggestion of the strife between the Body and the Soul; but yet another scene could be borrowed from ecclesiastical literature to turn again the scales of fate. Mercy hears the appeal of Mankind's soul, and is moved to pity. Justice, however, protests that Mankind should expect no pardon:

& euery man þat wyl Fulfyll
þe dedly synnys, & folw mysdede,
to graunte hem mercy, me þynkyth is no skyl;
& þerfore, systyr, ȝou I rede,
lete hym a-bye his mysdede. (3156–60)

This harsh judgment is sustained by the third sister, Truth. But Peace, the fourth, rebukes these advocates of unmitigated punishment, and persuades them to carry their dispute to their father, God. Accordingly, they present in full their arguments before his throne. Truth asserts that Mankind deserves damnation for his sins. But, Mercy interposes, Christ's sacrifice has made forgiveness possible. Such lenity, however, Justice objects, runs directly counter to divine law, and would be subversive of the whole moral order. Yes, adds Truth, Mankind never fed the hungry, or clothed the poor, or showed kindness to the unfortunate; let him therefore suffer. Thus the dispute progresses till Peace interposes. She reconciles the sisters, and together they beg God to spare the condemned sinner. In response to their united appeals, he orders Mankind to be carried from hell to heaven.

Thus the play ends with a dramatic rendering of the allegory suggested by the eighty-fifth Psalm. Like the allegory of the struggle between the virtues and vices, of the Dance of Death, and of the Debate between the Body and the Soul, this was one of the commonest themes of medieval literature. Combined as they are here, the four motives give in full the varied course of Mankind's career, from his first day, when Good Angel and Bad Angel stand on either hand asking his allegiance, through all his sinnings and repentings, to the last scene before the tribunal of God. The long story is told with but little respect for dramatic climax, and with a tedious prolixity; but underneath it all lies one plain moral:

> Evyr at þe begynnynge
> Thynke on ȝoure last endynge! (3648–49)

The reader thinks at once of the Blickling homily, "The End of the World is Near," and, possibly, of the still closer parallelism with a homily attributed to Ephraem, the Syrian.[1] It warns man to keep ever in mind the hour when soul shall be separated from body, and the great fear and the great mystery of life shall be consummated. At that hour, angels and demons will flock about the dying man, and struggle to possess him. If he has lived a good life, observant of the virtues, they will then become his *Angeli boni*, protect him from the demons, and lead him to a land of rest and joy. But if he has wasted his life, the vices to which he has yielded will become demons and seize his soul and carry

[1] *De habenda semper in mente die exitus vitae*, 6. 356–57.

it to unending misery. How closely the dramatist has followed the warning of the church!

The Castle of Perseverance, it is clear, should not be considered primarily from the dramatic standpoint. Its influence in the growth of the English drama can not be disregarded, it is true, by the literary historian. But he who would appreciate the type of which *The Castle of Perseverance* is the truest representative, should remember that its author and its first audiences knew nothing of the drama *qua* drama, and should study it first, according to its intention, as a piece of didactic literature, a "sermo corporeus." The student then realizes that the contents are not original with the English author, and that the primary sources should never be sought through the channels of secular literature, whether English or French, but rather in ecclesiastical literature, which knew no national bounds. If this be true of *The Castle of Perseverance*, it is equally true of the type it so perfectly represents. Here, then, is a clue for the investigation of the sources of the morality plays, and for a surer and fuller means for their intimate appreciation.

Chapter III.—The *Psychomachia*.

Thus the conception of spiritual life as a conflict between the forces of good and of evil, terminating in death and the final reward or punishment before the judgment-seat of God, constitutes the theme of the typical moral play, as it was devised to popularize and enforce the practical moral lessons that the Church had to teach. As the theme of conflict was obviously first in order of presentation, so it was first, without doubt, in order of development. The conception of life as an armed combat is as old as Christianity itself. It underlies many of the New Testament's warnings against temptation, especially the appeals of that virile apostle Paul. "For we wrestle," he wrote, "not against flesh and blood, but against principalities, against powers, against the rulers of the darkness of this world, against spiritual wickedness in high places. . . . Stand, therefore, having your loins girt about with truth, and having on the breastplate of righteousness; And your feet shod with the preparation of the gospel of peace; Above all, taking the shield of faith, wherewith ye shall be able to quench all the fiery darts of the wicked. And take the helmet of salvation,

and the sword of the spirit, which is the word of God."[1] Clearly the spiritual life meant to Paul a struggle not unlike the clashing of foes in battle.

The vivid picture that Paul here drew of militant Christianity was never forgotten. It was very plainly in the mind of that vigorous controversialist and ardent reformer, Tertullian, as he attacked the impurities of the Roman theater.[2] "Would you have also fightings and wrestlings? Well, of these there is no lacking, and they are not of slight account. Behold unchastity overcome by chastity, perfidy slain by faithfulness, cruelty stricken by compassion, impudence thrown into the shade by modesty; these are the contests we have among us, and in these *we* win our crowns."

With a still more lifelike personification and a more specific indication of the nature of the assault, this same conception was handled by Tertullian's follower, Cyprian. "What else in the world," he wrote, "than a battle against the devil is daily carried on, than a struggle against his darts and weapons in constant conflicts? Our warfare is with avarice, with immodesty, with anger, with ambition; our diligent and toilsome wrestle with carnal vices, with enticements of the world. The mind of man besieged, and in every quarter invested with the onsets of the devil, scarcely in each point meets the attack, scarcely resists it. If avarice is prostrated, lust springs up. If lust is overcome, ambition takes its place. If ambition is despised, anger exasperates, pride puffs up, wine-bibbing entices, envy breaks concord, jealousy cuts friendship; you are constrained to curse, which the divine law forbids; you are compelled to swear, which is not lawful."[3]

Of almost equal significance is the following excerpt from the *Divine Institutes* of Lactantius, the great churchman of the third and fourth centuries:

God, who created men to this warfare, desired that they should stand prepared in battle array, and with minds keenly intent should watch against the stratagems of open attacks of our single enemy, who, as is the practice of skilful and experienced generals, endeavours to ensnare us by various arts, directing his rage according to the nature and disposition of each. For he infuses into some

[1] Eph. 6. 11–17.

[2] 34. See Thompson, *Controversy between the Puritans and the Stage*, 13–16.

[3] *On the Mortality*, 455. See also Ephraem, the Syrian, *De Pugna Carnis*, 5. 232–34.

insatiable avarice, that, being chained by their riches as by fetters, he may drive them from the way of truth. He inflames others with the excitement of anger, that while they are rather intent upon inflicting injury, he may turn them aside from the contemplation of God. He plunges others into immoderate lusts, that, giving themselves to pleasure of the body, they may be unable to look towards virtue. . . . Moreover, those whom he has seen to be pious he involves in various superstitions. . . . Thus he has blocked up all the approaches against men, and has occupied the way, rejoicing in public errors; but that we might be able to dispel these errors, and to overcome the author of evils himself, God has enlightened us, and has armed us with true and heavenly virtue.[1]

These three passages indicate how the Church Fathers, visualizing clearly the conception of St. Paul, came to understand and portray the soul's resistance to temptation as a struggle between the forces of good and of evil. Such an idea, thus sanctioned by the New Testament and the immediate successors of the Apostles, could not be barren to an age already inclined to allegorical interpretation. Very readily the moral qualities that the apostle would set to oppose temptations, and the virtues and vices that Cyprian brought face to face, became living warriors engaged in hand to hand conflict with weapons of war. Most often the struggle was depicted as a conflict, epic in character, in open field. Sometimes, however, the more strictly religious writers, for reasons that will be explained, chose to represent the virtues in the act of defending their citadel, the soul, against the vigorous assault of the vices. With this possibility of variation, the theme spread rapidly and widely through the homogeneous intellectual world of the Middle Ages in Latin poems, sermons, and moral treatises, and more than any other one influence determined the character of the morality plays.

Each branch of the theme in the fourth century received its first treatment at the hands of the poet-churchman, Prudentius. He narrated in the *Psychomachia* the battle between the armies of sin and holiness, and sketched less fully in the *Hamartigenia*, as Cyprian had done, the siege of the soul. The former, after a preface explaining the typological significance of the history of Abraham, opens with words that remind one strongly of Tertullian and Cyprian:

"Tell us, O Christ, . . . our king, with what soldiery the mind may seek to drive the sins from the cave of the breast. When sedition arises to disturb our spirit, and sin wearies the mind with combat,

[1] *Divine Institutes*, Bk. 6, chap. 4.

what guard have we to insure our liberty, what battle-line can best withstand the furies that have penetrated our hearts? For you, good Leader, have not exposed Christians to destroying vices without giving them great virtues and courage to endure. You yourself order the defending hosts to fight in the besieged body; you yourself arm the spirit with strength to contend powerfully in your behalf, and to overcome the lusts that battle in the heart.

The actual combat then begins in a way natural to the fourth century, when heresy and sedition still menaced Christianity, and to an author familiar with the burning appeals of Tertullian. It is Faith who first takes the field, neglecting in her eagerness for glory in new battles to arm herself with the javelin, or cover her unprotected shoulders with a corslet. Idolatry at once assails her, but Faith smites the hostile head bound with crime, bearing to the ground the bleeding mouth, and trampling on the glazed eyes. Her victorious retinue, recruited from the thousand martyrs, exults, while Faith rewards all, according to their deserts, with floral wreaths and purple robes.

Next Chastity in gleaming armor meets on the grassy field the attack of Sodomite Lust, who tries to smirch her face and blind her eyes with the black smoke of her pitchy torch. But the unterrified virgin strikes the torch from Lust's hand with a stone, and with her sword cuts the throat of the disarmed courtesan. Black vapors rising from the bloody wound pollute the air, while over the lifeless body of the great tempter—"vexatrix hominum"—the victorious queen, after the copious epic fashion, exults in her triumph, which she likens to that of Judith.

At once attention is drawn to Patience, as she stands unmoved in the midst of the tumult and slaughter of battle. Wrath sees her from afar, the "Martis spectatrix libera nostri," and with ugly threats hurls his spear. It falls, however, harmless from the breastplate that the provident goddess has put on, and Patience remains undisturbed, a living embodiment of the virtue that Tertullian had so exalted. Then Wrath grasps his sword, and smites her helmet; but the blade is shattered, and in the fury of defeat Wrath slays himself with a spear which he snatches from the ground. Well, then, may Patience boast that, in her own peaceful way, without resort to weapons, she has triumphed over her foe. Meanwhile, her faithful supporter Job ceases from combat—such slight hints suggest the struggle raging about the protagonists—and together they pass through the army and leave the field.

In spite of these reverses, the vices continue to force the fighting.

Pride, clad in lion's skin and linen mantle that bellies in the wind, dashes up on a fiery steed. The few ill-armed troops that Humility and Hope have gathered arouse only her scorn, and, riding out between the lines, she heaps ridicule upon them for daring to face her, and boasts that she will trample them down—Justice, poor Honesty, meager Sobriety, spare Fast, Shame, Simplicity, and all the rest. These threats and scoffs Pride utters as she spurs her unbridled steed wildly between the lines, hoping thus to terrify her humble foes and override them. But suddenly her charger stumbles, and falls headlong into a trench, which Fraud, to entrap the moving squadrons, has dug and cleverly concealed beneath branches and turf. Hope, seeing her enemy's plight, runs hastily to Humility with a sword, and Pride's head is soon hanging by the bloodwet hair. "Cease to boast," cries Hope to her followers, "for God humbles the proud." Leaving this as her final message, the virtue flies on golden wings to heaven.

Thereupon Luxury, unmindful of her tarnished name, leaving a gluttonous feast, drives up in a chariot built of gold and silver, and studded with precious stones. A strange warfare this drunken, perfumed temptress, with her alluring eyes and languid voice, comes to wage. Instead of arrows and javelins she bears violets and roses, which she scatters from baskets among the Christian troops. Their limbs are weakened by the sweet odors, and they are ready to surrender, longing to serve under the debauched mistress and to be held by her lax, carnal laws. But Sobriety, smarting at such easy surrender, fixes the banner of the cross in the ground before the troops, and rouses their courage with reproaches and entreaties. Thus made mindful of their high lineage, and the greatness of their ancestors, the Jewish patriarchs, they advance. Luxury's horses rear and overturn the chariot, and she herself is caught in the whirling wheels. As Sobriety kills her with a stone, her frightened followers flee—Jest and Illwill throwing away their cymbals, which have served as weapons, Love casting aside its arrows, and Pride its splendor. The valuables thus discarded are left untouched, at Sobriety's command, to be trodden under foot.

But Avarice, attracted by the plunder, greedily gathers up the fallen treasure with her hooked hand, filling not only her ample bosom, but the money-bags and the basket that hangs by her arm. Care, Famine, Fear, Anxiety, Perjury, Pallor, Deceit, Falsehood, Sleeplessness, and Uncleanness, follow their mother like wolves; for with one or another of these children Avarice assails every class of men to its ruin. The priests of God, whom she dares to tempt,

are saved by reason from total subjection; but easily, by concealing her dread countenance under the guise of Moderation, she draws the unsuspecting soldiers into her toils. Rendered thus uncertain as to friend and foe, they give way, until Charity, although unarmed, attacks her. The virtue strangles her opponent, and stripping the booty from the corpse, gives it to the poor.

Having thus slain the parent of so many evils, Charity expounds the lesson which man should learn from the sparrows' simple trust in God. Immediately all care leaves the virtues, as the terrors of war vanish; the sword rests in its scabbard, and the field shines in the purple light of liquid day. The victors, led by Concord, return to camp singing joyful hymns, such as Israel sang when their pursuers were swallowed up in the Red Sea. The victory, apparently, has been won. But just as Concord is about to enter the stronghold, an enemy that has been lurking in the crowd of soldiers suddenly strikes her with his sword. The assailant is Discord, or Heresy, who has followed with murderous intent. Her attempt is foiled by the virtue's armor, and it only remains for Faith, the queen of virtues and the first combatant, to pierce the tongue of the blasphemer with her spear, and to deliver her to the soldiers to be torn to pieces and thrown to the dogs and birds of prey. The poem then closes with addresses by Faith and Concord, and by a prayer of thanks to Christ for his aid, and a look forward to his second coming, when sin shall be finally vanquished.

The literary value of this poem and its relation to classical epics, need not concern the student of the moral plays. To what degree and in what manner, though, it expressed the ethical ideas of the fourth century, and what its influence was on the late Middle Ages, are of great importance. In the first place, its conception of the virtues and the vices was very characteristic of its time. The struggle of Paganism against Christianity was as yet unfinished, and consequently the first of the theological virtues plays the leading role. It is Faith, remember, who begins the combat, and brings it to a close. The conception of Patience, moreover, corresponds closely to Tertullian's; and Charity, in accordance with the prevailing theology, is depicted both as almsgiving and as love of God. In the second place, Prudentius gave these personifications a symbolic realism that kept them long alive in letters and art. The final ascent of Hope to heaven; the hooked hand of Avarice; the unruffled self-control of Patience; the pomp of Luxury—all were too truly suggestive to be forgotten. They became the common property of poets and theologians, and proved readily adaptable to the needs of sculptors and painters.

The influence of the *Psychomachia* on later allegorical literature can hardly be overestimated, though now and again it may be traceable only in a brief allusion. A sermon, for example, in which the vices are said to attack man from the rear, while the temptations lure on from the van, owes its thought, more or less directly, to Prudentius.[1] Other works borrow and adapt more freely. A significant instance of such detailed imitation is the *Anticlaudianus*, a Latin poem of the twelfth century in which Alain de Lille combined the epic account of the spiritual combat with an allegorical treatment of man's intellectual qualities and of the seven liberal arts. It is at the end of the eighth book that the "divinus homo" whom God has created in response to entreaties of Reason and Prudence and to whom Nature has given a body, is assailed by the familiar forces of evil. Discord, supported by such vices as Livor, Rabies, Furor, Impetus, Ira, and many more, leads the assault, while Pride advances with her army. Meanwhile the virtues prepare to defend man. Discord, who makes the first attack, is decapitated, and her followers either perish or flee. Then in turn other vices attack and are vanquished, Luxury by Sobriety, Lust by Reason, Imprudence by Prudence, Fraud by Faith, and Avarice by Generosity. Thus all the vices are repelled, and the Golden Age, when man and nature are without blemish, is ushered in. The combat occupies but a part of this poem, in which pagan influences and medieval scholasticism do not conceal the dominating influence of the *Psychomachia*.

More complete and more interesting, possibly, than the *Anticlaudianus* is the thirteenth century poem, *Li Tornoiemenz Antecrit*. It is also more strictly theological, for the author, Huon de Méri, wrote to attack the Albigenses, who regarded Christ as the great impostor, and, like the Jews, awaited the coming of the true Savior. In the poem, the approach of Antichrist is heralded by his chamberlain, Bras-de-fer, who prepares the stronghold Desesperance for his lord's reception. There Antichrist feasts his evil followers, and entertains them with Satanic minstrelsy. Next day his army is assembled for battle; Jupiter, Mars, Neptune, and other "barons of hell" advance in company with Beelzebub and the long familiar vices of Christian allegory. No enumeration of their names could suggest the pains that the author gave himself to picture the soldiers of Antichrist, their numbers, their arms and banners. At the same time the army of Christ, composed of angels and all the other celestial

[1] *De Pugna et Pace*, Adam Praemonstrateus, *Patr. Lat.*, 198. 151.

orders, is marshaled in the city of Esperance. With the leaders, Michael, Gabriel and Raphael, are Mary herself, who has come to guard her chevaliers; Virginity, with a few followers; Chastity, with a numerous retinue; and the other moral virtues supported by all the chivalry of France.

Then the battle begins.[1] Quarrelsomeness laces on his armor, and with his standard-bearer, Frenzy, attacks Silence, but only to meet defeat. Anger is captured by Gentleness, while Frenzy succumbs to Patience. Hate and Discord fall before Peace and Concord, and Falsehood is put to flight by Truth. From both sides hordes of combatants mingle in the fray; for here the story is not confined, as in the *Psychomachia*, to the deeds of the few great leaders. But in the confusion of battle the conflict between Virginity and Chastity on one side, and Fornication and Adultery, aided by Venus and Cupid, on the other, draws more than passing notice. Of still greater interest is the struggle of Faith against Heresy, at which point the author reaches the heart of his theme.[2] The pagan gods, of course, fight on the side of Heresy, and Antichrist himself rides madly to his aid. But he is overcome by Saint Michael, and his army is routed. The virtues return triumphant to their city, where Penitence and Confession heal their wounds, and all join in the great feast spread by Generosity and Courtesy.

It would require an extensive monograph to follow the course of the *Psychomachia* through medieval literature. In the seventh century Aldhelm described the combat between virginity and the principal vices, whom he represents as military leaders.[3] Peter of Blois, in introducing Faith as man's advocate against the accuser, Satan, borrowed his picture of the virtue directly from the words of Prudentius.[4] Raoul de Houdan told how the pilgrim, as he journeys toward Paradise, is threatened by Temptation, and how he is saved from the attack of the vices only through the armed intervention of the virtues.[5] As the theme was thus developed, it lost its distinctively ecclesiastical tone. The French poet, Rutebeuf, retold the conflict briefly, less from a churchman's point of view than from the satirist's, and without any apparent moral purpose;[6] and Lydgate introduced it in a tediously prolix narrative poem, where the pagan

---

[1] 2093 ff.

[2] 2767 ff.

[3] *De Laudibus Virginitatis*, *Patr. Lat.*, 89. 110–13; also *De Octo Principalibus Vitiis*, *Ibid.*, 281, and Bonaventura, *De Pugna Spirituali, contra septem vitia capitalia*, 6. 21–27.

[4] See above 311.

[5] *Songe de Paradis*, 141–92, 541–98.

[6] *La Bataile des Vices contre les Vertus*, 20–36.

and the Christian are mingled in strange confusion.[1] Insufficient as they are, these few references will show how widely, and with what a variety of motives, the story of the *Psychomachia* was transmitted through medieval literature.

Without any additional evidence from sources more remote, it is interesting to read the same story of the opposition of vice to virtue as it was written in stone by the sculptors of the cathedrals. On account of the medium in which they worked, their rendering of the moral struggle was static, gaining its effect by visible contrast rather than by action. The virtues and vices are grouped in pairs, the former represented as dignified women, sitting composedly, as though filled with the peace of God, the latter as men or women under the sway of some uncontrolled passion. For example, Faith is seated on a bench holding a shield emblazoned with her symbols, a cross and a chalice. Opposite her is Idolatry—a man worshiping a monkey-shaped idol. Charity is represented in the act of giving her clothing to the poor, while Avarice greedily fills her treasure-box. Still more directly did the sculptors draw from the text of the *Psychomachia* for their image of Pride, whom they represented falling from a stumbling horse. In a second group of allegorical medallions on the north portal of the cathedral of Chartres, the triumphant virtues stand over the prostrate forms of their vanquished foes, as if in illustration of the close of the separate combats of the *Psychomachia*. So the contrasted virtues and vices are depicted in pairs on the façades of the great cathedrals, virtue being represented in its essence, and vice by its lamentable effects.[2]

For this method of contrast, which at first seems peculiar to pictorial art, one can find theological authority. In the instructions for the adaptation of discourse given in the *Pastoral Care*, Gregory placed side by side the psychological extremes—the lowly nature with the haughty, the peaceful with the quarrelsome, the kind with the envious. In a more vivid manner Isidore of Seville contrasted the virtues and the vices in pairs, Abstinence and Lust, Envy and Charity, and the like, with a brief exposition of each.[3] Likewise in the treatise, *De Conflictu Vitiorum et Virtutum*, which has been attributed to a half-dozen different churchmen, the author enumerates the full list of opposed virtues and vices. He then steps aside to

[1] *Assembly of Gods*, especially 603 ff.

[2] See Mâle, 132–59. In the fourteenth and fifteenth centuries the vices as well as the virtues were personified instead of being represented by their effects. See Mâle[2], 2. 1.

[3] *Sententiarum Libri Tres*, *Patr. Lat.*, 83. 638 (2. 37).

permit the contention to go on. Pride, the mother of vices, reminds the hearers that they are superior to most men in knowledge and position, and urges them to show a proper disdain for the lowly. But Humility at once interposes her warning. "Remember," she admonishes, "that you are dust and ashes, a worm. Are you stronger than the first angel? . . . If he for his pride fell from his seat of eminence, how can you, if proud, hope to rise thither from a lower level?"[1] In this debate, however, there is a dramatic movement that recalls us from the purely static exposition of Isidore and the sculptors to the action of the *Psychomachia*, and reminds the reader that in all these many versions of the one theme the influence of that poem is directly traceable.

There was, though, a second method of presenting allegorically man's inward struggle. Instead of risking their safety in the open field, the virtues, entrenched in their stronghold, the soul, resist the assault of the vices. This variation was especially popular with theologians in whom the moral inclination dominated the literary. To be sure, between the battle and the siege there is no essential distinction. The opening lines of the *Psychomachia* allude to such a siege, and Rutebeuf gave as much attention to one as to the other. But, since the fall of Jerusalem was commonly interpreted as an allegory of the downfall of the human soul before temptation, theologians were likely to select the siege as the fittest symbol of the nature of temptation.[2]

References more or less plain to the siege that the virtues are forced to undergo can be found in Cyprian and *The Pastor of Hermas*. But for a suggestion of action such as can make allegory of lifelike interest, one must turn again to Prudentius, who, even before writing the *Psychomachia*, had given in the *Hamartigenia* a dramatic sketch of the assault upon the soul. In that poem Prudentius traces the origin of evil, not to a god as did Marcion, but to a Satanic power whom he brands "the slave of hell." It is he who with enticements to evil leads the assault upon the soul, like a powerful robber besetting the troubled minds of men. Ire, Superstition, Grief, Discord, and kindred vices lead his cohorts, while other forms, misshapen and terrifying, press to their aid. "Relying on such strength, the destroyer subdues the minds of men and beguiles them to bend their necks to the yoke."[3] These

---

[1] See *Patr. Lat.*, 83. 1131–44.

[2] Hugo de S. Victor, *De Civitate Sancta Jerusalem*, *Patr. Lat.*, 177. 999–1003.

[3] 389–449.

lieutenants who fight under Satan are sexless, but they are truly allegorical, and must have given precedent for the symbol of the besieged soul.

Despite the influence of Prudentius, no ecclesiastic for many years adopted for extensive treatment the idea here expressed. It may be just as significant for the future, however, that it is found pervading a great work like Gregory's *Morals of the Book of Job*, as naturally as though it were essential to the Christian faith. In his preface Gregory explains that Job was beset from without by misfortune, and from within by the insidious counsel of wife and friends—Satan, as it were, leading an army to assail him with the battering-ram of temptation. Again and again he recurs to the idea.[1] Each separate sin, he asserts, lays siege against the mind, as its enemies besieged Jerusalem. Even if only one point is left unguarded Satan will find entrance, as he did in the heart of the proud Pharisee. But to fall in that way is really inexcusable; for to combat each vice man may find a specific virtue that will keep the city of the soul unshaken. Thus Gregory perpetuated the idea that Cyprian and Prudentius expressed, without the use of allegorical figures, to be sure, such as appear in the *Hamartigenia*, but with an increased emphasis laid on the distinctive character of the allegory—the siege.

We can not hope to trace the development of this branch of the allegory. Two instances will show how Gregory's teaching was given a more dramatic and sustained treatment by great churchmen of the twelfth century. Hugo of Saint Victor, in preaching on the watchfulness that the Christian should maintain against temptation, likens the goodman of the house, whom Luke mentions, to the mind; his home to the conscience; and his family to his five senses and his outward and inward acts. The great enemy or thief is the Devil, who, however, is not alone, for in opposition to each virtue is a vice. It therefore behooves the goodman to fortify his house against these thieves, placing at the first gate Prudence, then Bravery, and, well within the walls, Justice. These three must maintain a constant watch, lest the thief assail them unawares.[2]

The dramatic possibilities of this theme were much enhanced by combining it with the parable of the Prodigal Son. Especially

---

[1] Bk. 3. par. 12, Bk. 8. par. 8, Bk. 20. par. 53.

[2] *Patr. Lat.*, 177. 185. On Luke 12. 39. See also Bernard, *De Tribus Inimicis Hominis*, 5. 528–29.

significant for the student of the moralities is the version variously attributed to Hugo or Saint Bernard, in which a considerable portion of the parable is given in dialogue. A mighty king has endowed his son with all blessings. But the son abuses the greatest gift, the knowledge of good and evil, and, falling into the power of Satan, is chained in the prison of despair. The father, however, does not forget him, and although his first messenger, Fear, accomplishes nothing, he sends a second, Hope, who finally rouses the prisoner from the deadening grasp of sin and the fetters of bad habit. Helping him to mount the steed, Desire, and furnishing him with the saddle of Devotion and the spurs of Good Example, Hope encourages him to flee, while Fear drives him on. But, because a bridle is lacking, the flight becomes uncontrolled. Prudence and Temperance have then to check their rash haste, and supply the bridle of Discretion to make possible a more orderly retreat. Thus they advance, Hope leading the Prodigal Son, Force protecting, Prudence guiding, and Justice advising, till they reach at last the castle of Wisdom, within whose moat and walls they find refuge.

But Satan, like Pharaoh following the children of Israel, has been in close pursuit, and with his hosts at once besieges the castle. They mine the fortifications, they cast burning brands over the walls, they place ambuscades. The defenders are seized with fear, and Prayer, on the advice of Prudence and Wisdom, is hurriedly dispatched to the father for aid. Charity, who returns with the relieving party, arrives just in time to save the city from surrender. The son is then conducted to his father's home, where he is received with great rejoicing.[1]

The siege, then, as a symbol of the strife in man's heart between the inclinations to good and to evil, was just as widely accepted as was the theme of combat.[2] It seems to have been preferred by the more strictly religious writers, and therefore, though tangible evidence is insufficient to warrant such a deduction, may have been more commonly used in the didactic plays. The reader already knows how seriously the earliest extant morality handles the siege. The same episode appears again in the late play, *Mary Magdalene*, which is half miracle-play and half morality. It is true

[1] Bernard, *De Pugna Spirituali*, *Œuvres Complètes*, 4. 102–19. Gröber, 2. 1, 202, offers no conjecture as to the true author. Bourgain, 216, attributes the parable to Hugo de S. Victor.

[2] *The Pilgrimage of the Life of Man*, 11769 ff. and 15489 ff., and *Piers Plowman*, Passus 19–20.

that the text of that play barely alludes to the assault; it tells simply that Mary sought refuge in her castle, where she was besieged by the vices under the command of the World, the Flesh, and the Devil. But the stage directions state explicitly, "Her xal all þe vij dedly synnes be-sege þe castell." This, apparently, was the cue from which the actors were to carry through a scene long familiar on the stage.[1]

In no early play is there a representation of the epic combat in the open—the psychomachia proper. An interesting survival, however, of the popular *motif*, is found in the late fifteenth-century play, *Nature*. After the vices have gained control over Man, and while Reason is laboring to save him, Wrath and Envy present themselves before the five remaining vices "defensibly arrayed"; for they have heard rumors of a coming "fray" between Reason and Man. But the other sins are not so ready to enter the fray; from their characters, why should it be expected of them? Bodily Lust declares campaigning to be extremely irksome and fatiguing to him; Gluttony, though armed with a bottle, announces that he will stand well "out of danger of gun shot"; and Sloth takes to his bed, and pleads sickness to excuse him. Even Envy is not keen for fight, and in a spirit of mischievous malice persuades Pride, who appears late on the scene with a retinue for whose equipment he has mortgaged his estates, that the battle is already done, and that men accuse him of cowardly desertion. In this travesty of the *Psychomachia* the reader sees that Medwell, the author, had been so touched by the spirit of humanism that the old story seemed dramatically weak and uninteresting. Quite fittingly, Anger might thirst for battle; but it would be inconsistent for Sloth or Gluttony to desire any sort of exertion. Hence Medwell burlesqued the battle, and introduced Age to stifle man's lust and so reconcile the opposed forces. Never, though, would he have adapted the old theme in this way had it not been well known in its original form.[2]

---

[1] In a French morality, the Church is assailed by Heresy, Simony, and Scandal. Petit de Julleville, *Répertoire*, 66. In *The Contention between Liberality and Prodigality*, Prodigality attempts to enter Fortune's bower by a ladder; but she "claps a halter about his neck" and he falls, fortunately breaking the halter. This interesting scene probably owes nothing to these early plays. The play was printed in 1600.

[2] In a French morality, *Honneur des Dames*, Danger, Envie, and Malebouche attack Honneur des Dames and are defeated by her protectors, Franc Vouloir and Cœur Loyal. This is clearly a reminiscence of the struggle in the *Roman de la Rose*. *Répertoire*, 74.

But it would be blind to measure by these few direct survivals the influence of the *Psychomachia* upon the moral plays. The actual narrative of the poem was not dramatized any more frequently than the Dance of Death or the debate of Mercy, Truth, Righteousness, and Peace. One therefore calls Prudentius the father of the morality not because he supplied an episode for the allegorical plays of a later time, though that too he did; but because he established, if he did not actually create, the idea upon which all those plays were based.[1] The feeling that life is a spiritual combat between man's good and evil impulses, on whose outcome depends his destiny—that the Middle Ages owed to him. Furthermore, his method of dissociating those qualities from the soul, and bringing them as human beings into a visible opposition, offered the churchmen who would carry their precept to the theater the readiest means of dramatization. The hero, Man, was brought upon the stage, and surrounded by a number of men and women who represented the states of his inner life; he was deceived and debauched by the vicious characters, and aided, and usually saved, by the good. The dramatic method took the place of the narrative, and the realism of everyday life was substituted for the romance of the outworn epic; but in spirit and in general plan the morality plays were only a retelling of the fourth-century allegorical epic.

Chapter IV.—Theology in the Moral Plays.

Thus the whole Christian world came to think most intimately of man's spiritual welfare as dependent upon the triumph of the cardinal virtues over the deadly sins. The story of the *Psychomachia* was transferred without essential modification to the stages of England, and in an equally direct, though less open, manner influenced the moralities at their very inception, by virtually creating the allegorical idea that is the distinctive mark of the type. But in addition to supplying the allegorical conception of life as a combat, the poem also determined the character of the doctrinal lesson that the earliest known moralities sought to teach. To ex-

[1] It is wrong to stress, as Ramsay does (*Magnificence*, cli), the fact that the *Psychomachia* lacks the central figure around whom the moral play centered. The opening lines of the poem, as they have been quoted above, make in plain that the combatants are the impulses that dwell in man's soul, and that the story is a soul's history.

plain in detail how the allegory of Prudentius influenced the church's understanding of one of the corner-stones of its faith, will gather together all that has been thus far said of the influence of the *Psychomachia*, and of the alliance between the pulpit and the stage.

Very curiously, it may seem to the modern mind, the seven petitions of the Lord's Prayer, like the first seven Beatitudes, were connected with Isaiah's vision: "And the spirit of the Lord shall rest upon him,, the spirit of wisdom and understanding, the spirit of counsel and might, the spirit of knowledge and piety, and the spirit of the fear of the Lord shall fill him."[1] Augustine explains how the petitions of the Pater Noster call for this "sevenfold operation of the Holy Ghost," beginning with the last, which as the lowest in rank is the first for man to acquire, and leading up to those that concern the heavenly life.[2] The thought was universally adopted by the church, to be incorporated into such widely influential encyclopedias of doctrine as the *Glossa Ordinaria*, and such treatises as the *Speculum Ecclesiae*.[3] Thus the separate clauses of the prayer came to stand very definitely for seven spiritual traits; but, in view of this, they could not fail to be regarded also as antithetic to the seven deadly sins. Churchmen taught that the first petition was a call for protection against pride, the second against envy, and the others in order pleas against wrath, sloth, avarice, gluttony, and lust.[4] Accordingly, the figures of these seven virtues and seven vices hovered before the eyes of the children of the church, suggesting more or less vividly, according to the personal equation, the battle of Prudentius' poem. Here, then, one finds how directly the influence of the *Psychomachia* inspired the interpretation of one of the most fundamental portions of Christian instruction.

Even this superficial synopsis of medieval commentary will illustrate the nature and origin of the earliest known morality plays both in England and France. In 1384 Wiclif mentioned "þe paternoster in englizsch tunge, as men seyen in þe pley of York."[5] This piece is described by the records of the gild that had its performance in charge as "a play, setting forth the goodness of the

[1] Isaiah 11. 2. I translate from the Vulgate.

[2] *Our Lord's Sermon on the Mount*, Bk. 1, chaps. 3, 4; Bk. 2, chaps. 10, 11.

[3] Strabo, *Glossa Ordinaria*, *Patr. Lat.*, 114. 100–03. *Spec. Eccl. Ibid.*, 172. 819.

[4] Hugo de S. Victor, *Allegoriae in Novum Testamentum*, *Patr. Lat.*, 175. 774–87. Lib. 2, chaps. 3–14.

[5] *York Plays*, xxviii–xxix.

Lord's Prayer . . . in which play all manner of vices and sins were held up to scorn, and the virtues were held up to praise."[1] Likewise in the Pater Noster plays at Beverley and Lincoln the craftsmen of the towns represented on a series of pageants the cardinal sins, as they bore, it must be inferred, on the petitions of the prayer. The representation of Gluttony, for example, was fittingly assigned to the bakers, vintners, innkeepers, cooks, and tilers.[2] In France, also, the earliest known morality, performed at Tours in 1390, concerned the deadly sins.[3] Thus as early as the time of Wiclif, assuredly, the church's exposition of the Pater Noster was displayed concretely on the stage, "for the health and amendment of the souls as well of the upholders as of the hearers."[4]

As evidence of the importance attached by medieval churchmen to the teaching of the Lord's Prayer and the sacraments, no more conclusive or timely document can be cited than the Constitutions issued in 1237 by Grosseteste, the reforming bishop of Lincoln. This episcopal charge was modeled to conform to the Constitutions framed by Edmund Rich and the bishops in attendance with him at the Council of London, and to the canons of the third and fourth Lateran Councils in 1179 and 1215.[5] But while they specified in a more or less general way the qualifications that appointees to the different grades of clerical service should have, stressing especially the need for a thorough understanding of the sacraments, Grosseteste gave the most explicit commands. In the first of the forty-five articles of his charge, he stipulated that the clergy should be competent to instruct their parishioners in the Decalogue, the temptations of the deadly sins, the Articles of Faith expressed in the three creeds, and the significance of the sacraments. These points of doctrine were promulgated not only in formally declared "Constitutions," but in treatises like Archbishop Rich's *Mirror of the Church* and the widely translated *Somme des Vices et des Vertues*[6]; in religious poems like Grosseteste's own *Chasteau d'Amour* and

[1] *English Gilds*, 137 ff.

[2] Leach, 220–21. The first of the eight pageants at Beverley was given to "Viciose." Chambers conjectures (2. 154) that this figure was the representative of "frail humanity," who became the central figure of the later morals. See also Ramsay, *Magnificence*, cliii.

[3] Petit de Julleville, *Répertoire*, 137.

[4] *English Gilds*, 137.

[5] Stevenson, 132–38; Mansi, 22. 217 ff., 998 ff.; Lyndwood, 8–10, 55–56.

[6] Petit de Julleville, *Histoire*, 2. 178–82. Date 1279.

Lydgate's *Pilgrimage of the Life of Man*[1]; and in actual sermons, of which that of Archbishop Thoresby of York may be taken as representative.[2] Through all these channels, the points of doctrine that ecclesiastical councils declared most essential were conveyed to the masses of the people.

It is not surprising that the citizens of these ancient midland and northern cities should have undertaken to spread these doctrines through allegorical representation in the sacred plays for which they had received a long preparation in liturgical performances. The earliest of these moral plays, the Pater Noster play, the Sacrament play, and the Creed play, originated, significantly, in the region where these Constitutions were most ardently proclaimed by reformers like Grosseteste.[3] *The Play of the Sacrament* is not strictly a moral play, for its method is neither allegorical nor expository, but it should be mentioned as an indication of the popular interest in these subjects. The York Creed play, as far as can be told, more nearly resembled the Pater Noster play. Although nothing definite concerning it is known, save the fact of its performance once every ten years by the Corpus Christi Gild, the conjecture is not unreasonable that it was acted by twelve men representing the Apostles, to whom the twelve separate portions of the Creed were traditionally assigned by the theologians of the time.[4] If so, it was then but another dramatic piece devised to supplement the efforts of the pulpit.

These Creed and Pater Noster plays were presented by religious gilds under municipal supervision while the allegorical drama was as yet in its earliest development. The matter, though, that they contain was not soon dropped from the players' repertoire. The sixteenth-century play, *The World and the Child*, an abbreviated "full-scope" morality clearly modeled upon the general lines of *The Castle of Perseverance*, contains a systematic portrayal of the deadly sins, the Decalogue, and the Articles of Faith that were prescribed by the Constitutions of the early thirteenth century.

The hero appears first as a naked infant, and develops with incredible haste through boyhood and youth to manhood and old age. But after the brief account of the pranks of the boy and the temp-

[1] 6580–7036.

[2] In *Religious Pieces*. For similar French sermons see Lecoy de la Marche, 276.

[3] The northern versions of the *Cursor Mundi* contain these same doctrinal points, but the other versions, as far as I know, do not.

[4] Davies, *York Records*, 272–73, n.

tations of the youth, only the general allegory of sin and conversion that is found in the first part of *The Castle of Perseverance*, without the combat or the judgment, is presented. Thus the action of the play was made shorter and more direct, without essentially changing its didactic method; for the same direct relation between the play and the teachings emphasized in the Constitutions is apparent.

World is represented as giving his seven servants, the Deadly Sins, to be the companions of Man. But Conscience, after thoughtfully introducing himself to the spectators, undertakes to expose these vices in their true light. His doctrine is sound, but a trifle wearisome, and on his exit poor Man exclaims:

> yea, come wind and rain, (177).
> God let him never come here again.

Such feelings render him an easy prey to Folly's enticements, and he straightway experiences the carnal pleasures that the heroes of these plays so often crave. But since Conscience is not so straight-laced a moralist as to condemn rightly moderated pleasure, he and Perseverance are able to convert the rapidly aging sinner. Perseverance tells him how Peter, Paul, Mary Magdalene, and Thomas, after sinning grievously, repented and became saints. He declares, too, that for attaining salvation it is necessary to have rightly ordered both the five bodily and the five spiritual senses, as well as to accept the twelve Articles of Faith, which he enumerates, and to observe the Ten Commandments, which Conscience has already explained.[1] With this well-meant advice, the good counselors leave the hero with a prayer for Christ's mercy upon the audience. *The World and the Child*, in short, is a late morality, more dramatic, presumably, than the ancient Creed and Pater Noster plays of York, but written for the same end of enforcing the doctrinal teaching that Grosseteste and his fellow bishops considered so imperatively necessary for all men.

In a field of dramatic literature so completely dominated by the church, it is obvious that no one phase of its ecclesiastical spirit would appear to the exclusion of another. Hence, although the purpose of the Pater Noster play was primarily doctrinal, the inclusion of the seven vices gave opportunity for ethical instruction. This would be but natural; for one of the distinctive features of medieval religious thought was its twofold character. It embraced, on the one hand, a great body of doctrinal philosophy, whose end,

[1] Manly, 383.

it may be said, was largely faith, and, on the other, an equally large body of homiletic teaching, whose end was mainly works. Churchmen could with equal facility expound the powers that belong in particular to each of the members of the Trinity, or point a simple moral against idleness. Upon the useless subtlety and extreme impracticability of the theological speculation, our contemporaries are too prone to insist, even when they are most blind to the practical moral teaching that went hand in hand with it. A reminder, then, is often needed that in medieval religious thought there was this union of theology and morality, of the impractical and ephemeral and the practical and enduring, of faith and works.

The best single example of a play so combining doctrinal theology and practical ethics is the Macro morality, *Wisdom Who is Christ*. The first portion of the play is strictly theological; the second, which is not of present concern, is suggestive of contemporary society; the third is ethical.[1] In the first division, Wisdom introduces himself to the audience as a quality present in each member of the Trinity, but especially in the Son. She then explains to Soul how a man's psychic nature is composed of two parts, sensuality, as ruled by the five senses, and reason, the image of God. It is supplied with three distinct powers, Mind, which brings man to a knowledge of the Father; Understanding, which reveals Christ; and Will, which inspires love for the Holy Ghost. These senses and powers the dramatist has completely externalized in his allegory. The five senses appear as virgins singing a psalm; the three powers play leading roles; the soul itself appears, first in a white robe adorned with gold, then, after the powers have sinned, "in þe most horrybull wyse, fowlere þan a fende." In thus humanizing his abstractions, however, the dramatist has not forgotten his theology. The soul is still to him a psychic entity, doomed to suffer for Adam's sin, and saved only by Christ's Passion and by his own baptism. From its three powers come respectively Faith, Hope, and Charity, and opposed to them are the World, the Flesh, and the Devil. Above all else the soul has freedom of the will.

After Wisdom has expounded this orthodox psychology, Lucifer, in the disguise of a gallant, tempts Mind, Will, and Understanding by persuading them to despise the contemplative life, and to regard work as preferable to meditation and prayer. He even urges them to marry, and to enjoy riches and good clothing, for "Gode," he

[1] 1–552, 552–877, 877–end.

says, "lowyt a clene sowll & a mery." These are mild temptations, it seems to-day, but they were regarded then as sufficient to lead the powers to actual sin.

Thus the discourses of Wisdom and Lucifer, one laying the foundations of the whole play, the other getting the action started, are purely theological, and the characters are very far from being real beings. Pollard, therefore, calls the play intellectually weak. It is such only if we are willing to call all medieval theologians intellectually deficient, and one can regard it as such only through misunderstanding. Let us take from the play a single illustration. To be sure, the church did value most highly for those few superior minds the life of contemplation. For some, then, celibacy, self-renunciation, and other-worldliness, which Lucifer derides, were urgently insisted on. But for the world in general the active life was not disparaged. Augustine taught that both were essential, and that in pursuing the life of contemplation a man should not neglect the service due to his neighbor.[1] Bernard, likewise, exhibited the relations that bind together the two modes of life, and insisted that one should be able to turn from contemplation to action without succumbing to sin.[2] This doctrine was repeated in England by Richard Rolle of Hampole.[3] The harmonizing of the two courses of life is also beautifully rendered in stone on the north portal of the Chartres cathedral. Two large statues that once symbolized the active life and the contemplative life have been destroyed; but underneath still remain twelve little statues representing with the most naive and expressive realism certain typical duties that each may demand. On the left, six statues represent women cheerfully at work washing and combing wool, and preparing flax, by breaking and carding, for the spinning and the winding on skeins. On the right, six other statues show women praying, opening a book, reading, meditating, teaching, and sunk in a mystical revery. In the vaulting, apart from the series, but as a final expression of the contrast, are seen a shoemaker at work and a monk at study. Into these records of daily toil the sculptors could put all their creative force; for, though the church urged upon the few the transcendent joys of contemplation, it never slighted for the many the necessity of labor, or sought to depreciate it. All this would be a commonplace to the spectators who witnessed the performance

[1] *City of God*, Bk. 19. chap. 19. See also Gregory, *Morals*, 2. 433.

[2] *Œuvres Complètes*, 6. 101–02; 7. 270–74.

[3] 19–25.

of *Wisdom*; by them, therefore, the theological teaching of the play would not be misunderstood.

For the practical, ethical instruction that closes the play no such commentary is needed. Wisdom re-enters, and by earnest warnings seeks to reclaim the three erring powers of the soul. He speaks effectively of the necessity of contrition and prayer for forgiveness, and shows the futility of self-torture for winning salvation, as compared with the observation of nine simple duties most pleasing to God. These are: charity to the poor, sorrow for Christ's suffering, patience under reproof, watching for love of God, pity for the sick, restraint in speech, a feeling of responsibility for a neighbor's soul, prayer, and the love of God. By this simple homily the three sinners are reclaimed. If the teaching in the first portion of the play seems impractical, here, at least, is much good advice for right living. This contrast between the practical and the unpractical is very characteristic of medieval theology and homiletics, and it has been reflected plainly in the morality plays.

For the propagation of some specific doctrine and of piety in general, wealthy, play-loving cities like York and Lincoln could make permanent arrangements on an elaborate scale. But in a less pretentious way, any churchman could arrange for a simple dramatic entertainment to illustrate the truths that he was teaching. Such, doubtless, were the plays of whose performance in the open air on Sunday afternoons Bishop Bale bears witness. One specimen of such dramatized sermons the simple moral play, *Saint John the Evangelist*, has been assumed to be. It opens with a discourse by the Evangelist on the contemplative life, which he terms "the sweetest life." Almost immediately he returns to preach again on the Crucifixion, and at the end, giving little chance for any important action to intervene, he delivers a longer homily on the parable of the Publican and the Pharisee at prayer. From this he draws the identical lesson on the contrast between pride and humility that is found so universally in medieval commentary. The Pharisee's presumption in beginning his prayer with thanks rather than with confession; the fact that the three sins of which he boasts himself innocent really embrace all sin; the inevitable ruin that such pride brings—these were the common teachings of the church, just the simple lessons most suitable for short, open-air services. And indications are not wanting in the text that the play, like the sermons it would imitate, was given in the open. As John finishes his first homily, Eugenio makes the comment, "methinks I have heard you preach or this at Paul's Cross." Later, Evil

Council ventures the opinion, without any reference to an edifice, "we shall have a sermon or night." The inference is that this simple religious play was used as a substitute for the sermons so often preached in the open air on Sunday afternoons.

The substance of this chapter may now be briefly summarized. As the ecclesiastical playwrights drew from the *Psychomachia* the allegorical conception of spiritual life that prevailed in every play, so from it they derived also the understanding of the Lord's Prayer that they sought to expound in the earliest known play. Other similar lessons, especially those emphasized by Robert Grosseteste, were dramatized in exactly the same spirit. To the doctrine thus introduced to form the bone and sinew of the Pater Noster plays, *Wisdom* and other early moralities, as well as later plays like *John the Evangelist*, remained true. In thus holding close to the text-book of the church, the morality plays reflect truly and adequately the spirit of medieval theological thought.

Chapter V.—Contributory Allegories.

Although the *Psychomachia* established the conception of spiritual life as an open conflict between the externalized and allegorized traits of man's soul, and determined, too, the special teaching of the earliest Pater Noster plays, that poem was not the only influence upon the allegory of the rising religious drama. The taste for allegory was so literally part of the web and woof of medieval thought that other themes were adapted in the same way for dramatic presentation. But where the *Psychomachia* must rank as a creative force, these others should be regarded as secondary or contributory. The medieval debates—*débats*—gave only an indirect stimulus to the revival of dramatic literature, and certain allegorical themes drawn from the religious thought of the age to furnish episodes for the drama seem distinctly dependent upon the theme of conflict. Ramsay believes that these themes, the *Dance of Death*, the *Debate of the Body and the Soul*, and the dispute between Mercy and Truth, Peace and Righteousness, at first occupied a position equal in importance to that of the *Psychomachia*.[1] But they serve, in substance, as sequels to the theme of conflict, and do not stand naturally alone. Those few plays, like *Everyman*, not actually grounded upon the conflict, are at least dependent upon it.

[1] *Magnificence*, cxlviii.

The comparative frequency of these other themes, therefore, in the few extant early plays should not lead to the displacement of the *Psychomachia* from the position to which its general historical importance, its influence on the earliest known morals, as it has been shown, and its evident influence upon this whole dramatic type, have raised it, in favor of these other religious topics which were added to the fundamental theme to extend and diversify it.

The debate, which should be regarded as the least direct of these secondary influences, came to the Middle Ages from the secular literature of classical antiquity. In the pastoral poetry of Theocritus and Virgil it had become a stereotyped form, and in the work of the philosophers a recognized means of instruction.[1] This alone would have given it the seal of authority for the Latinists of the Middle Ages, who ranked Virgil so highly. But the debate was handed on not alone through the channel of established literary tradition, but also along the devious paths of popular minstrelsy.[2] This type of poem, therefore, was widely disseminated through Europe, both in the formal literature that would bow to the tradition of Virgil or the philosophers, and in the popular poetry that responded to the tastes of the people. One understands, then, how certain themes, like the debates between the Body and the Soul, Winter and Summer, and Wine and Water, made their way into so many different literatures; and one can easily see that this sort of poetic dialogue, as adapted especially by the minstrels, would unquestionably figure in the renaissance of the drama.

The universal vogue of the debate in medieval literature causes some scholars to regard it as the broad type of which the moral combat was only a specialized form.[3] Between the two, indeed, existed a sort of kinship in dramatic potentiality, and an adaptability for allegory. But the inspiration of Prudentius came in matters of literary form from the classical epic, in spirit from the New Testament and the Fathers; and as long as the theme of allegorical combat retained its original seriousness, it withstood noticeable modifications from the debate. The two literary traditions were advancing along closely adjacent, but parallel, courses. Only when the machinery of the *Psychomachia* was applied to themes more and more trivial was cross influence felt. This is not plain in the *Bataille des Sept Arts*, for at a time when ignorance as well as sin were attributed to Adam's fall, Henri of Andeli's theme was

[1] Jantzen, 2–4.

[2] Ibid., 22.

[3] Gaston Paris, 176–77.

not altogether alien to the matter of the *Psychomachia*. But the *Bataille d'Enfer et de Paradis*, in which the principals are represented by their respective champions, the cities Arras and Paris personified, and especially the *Bataille de Karesme et de Charnage*, which may be called the mock-heroic of this literary genre, owe, I think, less to the *Psychomachia* than to such pieces as the debate between wine and water. These trivial combats, however, are plain perversions of the theme; serious combat-literature, which alone had influence on the early morals, was unaffected by the debate.

One illustration may make the matter clear. In the *Bataille* that we call the mock-heroic two great barons meet at court, one Karesme (Lent), the other Charnage (the period when flesh may be eaten). Lent is haughty and insults Flesh-Time, and, when he retorts angrily, orders him from the palace. But the supporters of each are hot-headed, and blows follow words, so that the poem, which promised at the outset to be a mere debate, becomes a chronicle of actual conflict, in which the whale, the herring, and all the other "chevaliers de mer" fight with Lent, while choice cuts of beef, pork, and venison, rally to Flesh-Time's aid. The catalogue of combatants is tediously drawn out, the poet being evidently a gourmand with no taint of Fletcherism. Suffice to say, the battle is long and hard—so the reader is told—and Lent is decisively worsted, largely because Christmas with her "bacons," the Bluechers of the day, arrive in time. Lent is forced to come to terms of submission, and becomes the vassal of Lord Flesh-Time.

Such was the contamination that the theme of moral conflict suffered from the debate; but, since the contamination did not affect the serious moral combats that alone would inspire the early moralities, the debate should be studied as an independent influence upon the drama. The form of the debate is essentially dramatic. In some poems the author himself reports a controversy that he professes to have heard; in others, the contestants themselves carry on the dispute, debating vigorously the *pros* and *cons* of a question that one puts formally to the other. The subject-matter was varied —though not so much as one would expect; but whether it was secular or religious, trivial or significant, the form was always in essence dramatic, necessitating the use of dialogue, however crude or tedious, and giving opportunity for a suggestion of complication and action. Unquestionably, therefore, the debate must have furthered somewhat the rise of the regular modern drama.

Many debates, of course, were too simple to reveal any of the dramatic possibilities that were latent in the class. What these

possibilities might really be is shown in the *Debate of the Carpenter's Tools*. A mutiny arises in the shop when half the tools declare their master to be too shiftless and unsteady to deserve their support. The other tools, however, although they cannot deny that their master

> loves gode ale so wele
> That he þerfore his hod wyll selle,
> Fore some dey he wyll vii^{d} drinke, (75–77)

are still true to his interests. This simple dramatic complication is thereupon carried by the poet to a distinct climax when, after the "crow," the "pleyne," and the "squyre" have decided to seek a better master, the carpenter's wife breaks in, with curses on the priest who bound her "prentys,"

> And i myght, so wold i. (266)

A fuller knowledge as to the minstrels' methods of reciting these popular pieces might possibly disclose a connection between the debate and the drama in matters other than form. There is slight evidence here and there in contemporary records that some minstrels used gestures, facial masks, and, wherever ecclesiastical law was not rigorously enforced, clerical robes to aid them in impersonating the participants in the debates.[1] There is also no reason for rejecting as impossible the assumption that sometimes two or more minstrels carried on the debate. Jantzen, moreover, calls attention to several early German plays that are simply slight modifications of debates, and I shall point out bits of similar literature embedded in English morality plays.[2] But traces of such direct borrowing are rarely found; for the substance of the typical debate was too trivial to serve the serious didactic purpose of the drama, and the larger part of the repertoire of the minstrels has been lost.[3] Nevertheless, since these same minstrels were also agents in spreading the seeds of the actual drama, one can realize the strength of the debate's unseen influence in charging the spirit of the twelfth and thirteenth centuries with dramatic instinct.

In this same general way the debate contributed to the rise of the morality plays. It had always shown a capacity for personification. The λόγος δίκαιος and λόγος ἄδικος of Aristophanes' *Clouds* are embodiments of moral abstractions like those which acted on the medieval

[1] Chambers, 1. 81–83.

[2] Jantzen, 92–95. See below 346, 354.

[3] Ibid., 22; Herford, 22.

stage. These personifications sometimes leave their trivialities in order to debate themes strikingly similar to the subjects of the moralities. The Synagogue and the Church, for example, in one Old French poem, and the Jew and the Christian in another almost identical piece, after a few rude personalities, argue seriously on the proper interpretation of Isaiah's prophecy and on the significance of Christ's Passion.[1] In the latter debate the Jew is converted to the true faith. If these poems suggest comparison with those plays which, with a more or less liberal admixture of abuse, conveyed instruction in points of doctrine, often with immediate good results, the dull little piece, *Marguet Convertie*, offers resemblance to some of the more purely ethical sacred plays which deal with the contrast between the unlicensed desires of youth and the experience and premonitions of age. The young woman who at first taunts an old man for his physical weakness, is finally brought by his warnings to see her wrong-doing and repent. Finally, to offer but one more example, the *Debate of the Body and the Soul*, in its simple yet noble piety, would have given inspiration to the best of the morality plays. In general, the religious debate and the moral play enforce the same doctrine, the same warnings, and the same faith.[2]

This correspondence, however, in spirit and subject-matter between certain debates and the typical moral play does not indicate that one was derived from the other, for the same correspondence marks all phases of medieval religious feeling. For instance, the last lines of *The Body and the Soul*, the closing scenes of many moralities, the carvings on the portals of the cathedrals, all tell the same story of the fate of the damned. Giving direct expression, as they do, to the teachings of the church, they naturally are in agreement. This is all that can be postulated as to the connection between the religious debate and the moral play: as the debate in general, apart from the few instances of direct influence now known, encouraged the use of the dramatic form, so the debate on sacred subjects must have done something to spread the lessons of the church, and thus to supplement and strengthen the teachings of the moral plays. But this indirect support was hardly necessary, so familiar were the authors of the plays with their proper subject-matter, and at most the debate's influence on this branch of the drama was slight.

The influence of John Heywood, however, established a clearly marked cross-influence between the debate and the less serious

[1] See Bibliography, and *Hist. Litt.*, 23. 216–17.

[2] For the controversial debate of the sixteenth century see chap. 6.

moralities of the sixteenth century. His interludes, *Witty and Witless* and *Of Gentleness and Nobility*, which are only dramatized dialogues, were not too remote from the allegorical plays to exert upon them an influence. In the *Play of Love*, one of the characters takes the familiar part of the vice, and the contention carried on by The Lover Loved, The Lover not Loved, The Woman Beloved not Loving, and Neither Loving nor Loved, was doubtless imitated by the author of *All for Money* in the strife among Learning without Money, Learning with Money, Money without Learning, and Neither Money nor Learning. Other more significant specimens, though, of the debate are to be found in these plays. The two characters Wealth and Health, in the play that bears their names, carry on a perfectly obvious dispute in which one belittles the other and praises himself, and then come to an agreement in time to scoff at the pretensions of Liberty, who would uphold his own title to precedence. Formal judges are sometimes appointed by the disputants. In *Magnificence*, Liberty debates with Felicity to prove that he should not be subject, as Felicity has maintained, to external control, and Measure, who has been appointed judge, decides against his claims.[1] In several plays it is the vice who starts the dispute, and acts as arbiter. Contempt, the vice of *The Coblers Prophecie*, brings the three representatives of the social orders, Landed Gentry, Courtier, and Scholar, into argument; in *Like Will to Like*, Nicholas Newfangle hears Tom Tosspot and Ralph Roister debate their claim to the title, "the verier knave."[2] But even these formal debates play no essential part in the plays. For this reason the dispute in *King Darius* is of greater importance. Told to name and defend what they regard as the strongest influence upon man, one disputant suggests and upholds wine, a second, the king, and the third, woman. The last contestant is awarded the decision because he has spoken without flattery or deceit—a moral ending of the incident which Equity and Charity carry further in a final admonition and a religious song. But even here, where the debate is fused with the didactic lesson, it cannot be said to influence largely the action of the play.

Of the religious *motifs* that were tributary to the main current of the allegorical drama, the least important and the most remote from the theme of the *Psychomachia* is the legend of Antichrist. The legend, to be sure, foretells a great world-struggle with Antichrist, the incarnation of all the vices. But it is because the

[1] 24–162. [2] 317–26.

most complete dramatization of the story is also the earliest play in which allegory is used, that it deserves consideration here.[1]

The origin of the legend of Antichrist is hidden in remotest antiquity. It certainly was not, as its name may seem to indicate, an outgrowth of Christian eschatological speculation; for at the hands of Jewish theologians it had received full development before the beginning of the Christian era.[2] Nor may one suppose that the legend is no older than the writings of the Old Testament; for, hypothetical as are some of the theories of Gunkel and Bousset, they come little short of proving that it is only an anthropomorphic version of the old Babylonian myth, the story, transformed, of the dragon who waged war on the gods in heaven.[3] It would be futile, however, in this connection to follow in detail these excursions into Oriental folk-lore; the Christian interpretation of the legend grew from certain prophetic writings of the Old Testament, and from certain incidents in the history of the Jewish people.[4] It is enough, therefore, for a student of medieval religious teaching to know the belief regarding Antichrist that prevailed among the later Jews and early Christians.

The earliest versions of the legend in the Bible represent Antichrist not as a single personality, human or superhuman, but as a power for evil lodged in a hostile rival nation. By these heathen foes the chosen people, for their faithlessness toward God, are assailed and oppressed until God himself sends relief. "It shall come to pass at the same time when Gog shall come against the land of Israel, saith the Lord God, that my fury shall come up in my face. . . . Surely in that day there shall be a great shaking in the land of Israel."[5] Such is Ezekiel's conception. It was soon transformed in certain essential respects by the subjection of the Jews to the rigorous persecutions of Antiochus IV.[6] The pagan races were then no longer depicted as instruments of vengeance in the hands of Israel's angry God; they were made to appear as a power for

[1] There were other dramas on Antichrist, not allegorical. A play on Antichrist in the Chester cycle was assigned to the dyers. Another English miracle-play on the subject has been printed by Collier (see bibliography). I have read, also, a German play of the fifteenth century, *Des Entkrist Vasnacht.*

[2] *Jewish Encyclopedia.* [3] Bousset-Keane, 13, xi–xxvi.

[4] *Realencyklopædie*, from which I adopt the threefold division of the history of the legend.

[5] *Ezekiel*, 38. 18, 19. See the whole of chaps. 38, 39.

[6] See *Encycl. Brit.* for details. Date, 2ed century B. C.

wickedness opposed to the purposes of God. In this spirit Daniel foretold the coming of that "fourth kingdom," the kingdom of Antiochus, that should "devour the whole earth," and the might of the Romans, by which the righteous should "fall by the sword, and by flame, by captivity, and by spoil.[1] Thus the legend was modified by the hardships and humiliations that the Jewish nation experienced. But Daniel, like Ezekiel, still expected the oppression of Antichristian might to come, not from a single Satanic individual, but from some neighboring heathen kingdom or kingdoms.

This the first stage in the Biblical treatment of the prophecy was greatly modified as the Jewish people were taught to await the advent of a personal Messiah. For if God, instead of coming in person to relieve them, was to send his son as Saviour, then naturally Satan would be expected to delegate his powers to a lieutenant in all respects the counterpart of the Messiah.[2] Consequently, if the Messiah was conceived as a victorious king, an Antichrist was foreseen who should assail Israel in armed battle. When, however, the prophetic, law-giving character of the Messiah was emphasized, the popular conception of Antichrist underwent a corresponding change. Moses and Balaam, the false prophet, became then the types of Christ and Antichrist. And when the Jews finally expected not simply a king or a prophet, but a heavenly being, then Antichrist became to them an emanation of the Devil.[3] Such an understanding of the nature of Antichrist was made easy by the prominence given in the prophecies to Gog and Antiochus as leaders of heathen foes; it was rendered inevitable by the faith in a personal Messiah.

This belief, that the world immediately before the second coming of Christ was to be dominated by the terrible will of an Antichrist, is carried by the writers of the New Testament through its third and final stage. The most characteristic feature of the second, to be sure, was retained by the author of the Apocalypse, who predicted that Antichrist would come in the form of Nero, or some one Neronic emperor, and by Paul, who, whether or not with any historical personage in mind, thought always in the singular of "the man of sin." But even here the influence of Christianity left its impress in an intensifying of the antithesis between the Messiah and his great opponent.[4] In other respects the New Testament made

---

[1] Daniel, 7. 23; 11. 33. Also chap. 8.

[2] *Realencyklopædie.*

[3] Schneckenburger, 408–11.

[4] *Realencyklopædie.*

more important alterations in the story. Both Christ and his followers gave up the idea that the evil power was to come from some remote land, in order to impress upon their disciples the immanence of the evil principle in their very midst. It was also natural that, as the teaching of Christ dissociated the interests of the kingdom of God from those of the Jewish theocracy, the tradition should lose much, if not all, of its political significance, and assume a purely spiritual import. Therefore, although Christ grounded his warning of coming woe on the political prophecy of Daniel, the Antichrist that he foretold was to be no foreign king, destined to humiliate and overthrow the Jewish theocracy, but a false prophet sprung from the Jews themselves, and not one, but many.[1] For, as the tradition was thus spiritualized, the Antichrist again lost his personal identity, making himself felt, however, at this time not vaguely in some foreign enemy, but intimately in all Jews who gave themselves to evil. The Johannine epistle, in which the name Antichrist is first used, plainly states that all who deny the Father or the Son become themselves Antichrist.[2] Thus John gave his authority to a distinctly new conception of the Antichrist, and, as Paul was the last great Biblical exponent of the older idea of a single Antichrist, John became the virtual founder of another school of thought. But both these great Christian leaders were at one in emphasizing, as earlier thinkers had not done, the moral and ethical meaning of the legend—the opposition of sin to holiness.

These two understandings of the nature of Antichrist were carried on in the teaching of the medieval church. Origen, among the Fathers the most influential follower of the Johannine exposition, was by no means alone. But in the western church the more concrete understanding of the Satanic power exerted the greater influence, though what of the legend's political significance was retained was entirely changed. Only the Jews, through their unending hatred of Rome, preserved the tradition that Antichrist was to spring from that empire.[3] The Christians, on the contrary, after the conversion of Constantine, forgot entirely the historical application of the visions of the Apocalypse, following, as Bousset suggests, an older version of the legend that antedated Rome's persecutions of the new religion, and looking for the coming of Antichrist to the

[1] See Matt. 24. 15–31. Here and elsewhere the New Testament is said to preserve the tradition of a non-political, purely eschatological, Antichrist (Bousset, 182–88).

[2] John 2. 22, 4. 3.

[3] See quotations in *Jewish Encyclopedia*.

Jewish people.[1] He was to be born in the city of Babylon of a Satanic woman of the tribe of Dan. In his thirtieth year he would go to Jerusalem, where he would rebuild the temple and proclaim himself king. Through gifts, or force, or miracles, he would compel the whole world to acknowledge him the Christ. But after three and one half years of this rule, the angel Michael would be sent by God to slay the impostor, and to usher in the short period of peace that would precede the end of the world.

It was of course the concrete, rather than the psychological, interpretation of the prophecy, that proved most suitable for art.[2] Of the several dramatic versions of the story, only the twelfth-century *Ludus de Antichristo*, the earliest play in which allegorical characters appear, need be considered. Being based on the treatise of Adso, it embraces all the incidents mentioned above, but shows in its political signification modifications due to the revival of the western empire.[3] This historical bearing of the plot has been clearly analyzed by Creizenach,[4] and it remains to point out only the respects in which the play seems a forerunner of the morality.

In the *Ludus de Antichristo* there are seven strictly religious or ethical personifications, Mercy and Justice, Hypocrisy and Heresy, Heathenism, Synagogue, and Church, and in addition one or two historical personifications, such as Babylon. In word and deed they resemble the similar characters of the moralities. Notice in the first place that the religious teaching of the play is presented by these abstractions as though such matter were perfectly suited for the drama. The play opens with this characteristic combination of dramatic action and moral instruction. Heathenism and Babylon enter singing, but their theme is a strictly argumentative defense of polytheism. To believe in one God is to suppose foolishly that from a single source emanate all those widely different manifestations of divine power that man experiences. Gifts as diverse as the blessings of peace and the horrors of war force one in all reason to recognize deities of unlike will and power. In the same fashion, Synagogue and her party of Jews express in song their faith in one God, but their distrust and detestation of the self-professed Saviour of men who could not save himself. And so also Holy Church, who appears as a queen in armor, attended by Mercy with

[1] Bousset-Keane, 128–30, 184–87. Wadstein, 125–36, gives a good review of the church's teaching.

[2] Cf. the painting of Signorelli at Orvieto.

[3] Bousset-Keane, 131, and also 47–50.

[4] 1. 81–86.

the cup of oil, and by Justice with sword and scales, sings a song, indicated in the text simply by the words, "alto consilio," which, from her attendants' response, "This is the faith that gives life and overpowers death; those who believe it are not damned," must be a recognition of the Trinity. Such attempts to convey abstract truth on the stage are characteristic of the morality plays.

Equally characteristic of the moralities are the parts assigned to the personifications in the development of the plot. Hypocrisy undertakes to seduce laymen, and Heresy to mislead the clergy. With them is associated the group of Hypocrites, who represent half allegorically a type. On the other hand, at the end of the play Holy Church receives the mortals who have been rescued by the two prophets from their subjection to Antichrist, and brought back to the true faith. On either side, these are the parts soon to be conventionalized in the morality play. Had the legend been more often handled in this way by the dramatists, it would rank as one of the more important influences upon the allegorical drama; as it is, it may be regarded as a slight, but independent, contributory influence.

The other religious allegories that were incorporated into the morality plays, usually in dependence upon the theme of the *Psychomachia*, may be handled in chronological sequence. The first is the *motif* of the Dance of Death, which was so widely used in the literature and art of medieval Europe. The coming of Death to summon to judgment King and Bishop, Courtier and Scholar, Merchant and Peasant, was painted on the walls and windows of churches, as at Lübec and Salisbury, on the walls of graveyards, as in the Dominican convent at Basle, in illuminated service-books, and in Switzerland even on bridges and the façades of private houses. The earliest known treatment of the Dance of Death is a short Latin poem of the early fourteenth century, in which representatives of the different orders of society, in due order, utter complaints on death and go to suffer the ordeal. Death itself does not appear, yet the poem reminds one of the medieval dramas, like the Prophet Play, whose actors come upon the stage one by one, speak their parts, and disappear.[1] It is thought that the literary treatment of the theme had its origin in the *tableaux vivants* that were so popular during the thirteenth and fourteenth centuries in France and Flanders.[2] The earliest extant texts, it seems, enable

[1] Mâle[2], 390–91. Mâle's whole discussion of the Dance of Death should be read as the latest treatment of the subject.

[2] Seelmann, 11–21; Creizenach, 1. 461–62.

the scholar to postulate a French version of the legend dramatic in form. In these texts, Death gives his summons in the first line, and receives the answer of his victim in an eight-line stanza. To this Death replies in the first seven lines of the next stanza before turning in the eighth to the second victim. By this arrangement there is provided but a single figure for Death, instead of one for every scene as in the pictorial representations of the allegory, and this one figure was the moving force and the center of a bit of truly dramatic action. From this comes the deduction that the earliest Dance of Death was a dumb show or tableau accompanied by simple words of warning. But, according to Mâle, this drama had its roots in medieval homiletics. He shows that several early mural representations of the Dance of Death depict first, before Death is painted, a preacher as he addresses a group of worshippers, and then Adam and Eve as they eat the forbidden fruit. Mâle concludes that the drama had its origin in a sermon on death which the preacher illustrated by simple acting.[1] If so, another line of connection between the stage and the pulpit has been found.

Appreciating the forcefulness of these earliest mimetic representations of the Dance of Death, especially as a warning of the sequel of an ill-spent life, the authors of the moralities gave it their attention. "Here begynneth a treatyse how the hye fader of heuen sendeth dethe to somon euery creature to come and gyue a counte of theyr lyues in this worlde and is in maner of a morall playe," reads the title of our finest sacred play. Upon the closing scenes of man's earthly life the author focuses attention. The homiletic exposition of the sacraments and of confession is reduced to a minimum, and the early part of Everyman's life of pleasure is given only by suggestion. With a sense of unity rare at that time, the play dwells on its one theme—death.

The grim messenger sees his victim:

> Lo, yonder I see Everyman walking:
> Full little he thinketh on my coming:
> His mind is on fleshly lusts and his treasure;
> And great pain it shall cause him to endure
> Before the Lord, heaven's King. (95)

In vain the victim seeks to escape, or to find a companion:

> Oh, to whom shall I make my moan,
> For to go with me in that heavy journey?

[1] 391–93.

First Fellowship he said he would with me gone;
His words were very pleasant and gay,
But afterward he left me alone.
Then spake I to my kinsmen all in despair,
And also they gave me words fair,
They lacked no fair speaking;
But all forsake me in the ending.
Then went I to my Goods that I loved best,
In hope to have found comfort; but there had least:
For my Goods sharply did me tell,
That he bringeth many in hell. (107–8)

It is his fortune, at this crisis, to meet Knowledge, Confession, and other virtues who prepare him for his end. As he dies, an "Angel is heard speaking":

Now thy soul is taken thy body fro,
Thy reckoning is crystal clear;
Now shalt thou into the heavenly sphere. (121)

Yet even *Everyman*, confined as it is to this one situation, is not without dependence on the theme of conflict. To depict the sequel of a misspent life, a losing struggle with the vices, the author has selected from a variety of possible characters, good and bad, that this allegory usually embraced, the wild gallant whose career best served as warning. Turn from virtue to vice, as Everyman did, and only a repentance like his, a turning again to the virtues as in the typical combat-play, can save you, is the moral of the piece.

I would not press too insistently for this play the dependence on the *Psychomachia* that is more evident in the earliest English morality of which any part remains. In *The Pride of Life* it is the King who is seized by Death after a life of wilful disregard of God's law. Conscious of his power, and trusting in his two knights, Might and Health, he has disregarded Death. When the queen has reminded him that all men must die, and that every one, therefore, should

loue god & holy chirche
& haue of him som eye [reverence], (187–88)

the King but boasts more proudly of his power. At the request of the queen, the bishop then reproaches him, warning him that the world has turned to evil, and that the fear of God has been lost in falsehood, treachery, and oppression. But hell awaits the wrong-doers, he adds, where, without any chance for bail or a stay of proceedings, as in earthly courts, unending woe is prepared for kings

as well as common people. Even this warning is wasted, for the king calls the bishop a babbler, and urges him to learn to preach better. Here the text breaks off; but the prologue tells how Death, after first sending a messenger, wrestles with the king, and overthrows him, and gives his soul to the devils.[1]

The vivid conception of the coming of Death with his summons to judgment, gave rise to another closely allied allegorical *motif*, the *Debate between the Body and the Soul.* The popularity of this theme, however, in the lyric poetry of Europe did not gain for it any important place in the drama.[2] In only two English moral plays are traces of it found. Toward the close of *The Pride of Life*, the Virgin begs Christ to allow the King's soul to dispute with his body, and thereby gets a reconsideration of his sentence, and his eventual release from the hands of the devil. Of the incident, unfortunately, there remains only the outline in the prologue. Another trace of the same theme is found in *The Castle of Perseverance*, when Soul crawls "from beneath the bed under the Castle," and reproaches Body for his sins.

> body! þou dedyst brew a byttyr bale,
> to þi lustys whanne gannest loute;
> þi sely sowle schal ben a-kale;
> I beye þi dedys with rewly rowte;
> & al it is for gyle.
> euere þou hast be coueytous,
> falsly to getyn londe & hows;
> to me þou hast brokyn a byttyr jows;
> so welaway þe whyle! (3013–21)

The debate in both plays follows the mission of Death, and with it covers one crisis in the spiritual life of man.

But no one of these three important English plays that represent allegorically the coming of death closes the story of man's life with that point. As that incident looks back, implicitly at least, to the record of a misspent life, a losing struggle with the vices, so in Christian dramaturgy it could not but look forward to the possibility of salvation. Another episode, therefore, was necessary to give the last stage of the pilgrim's progress. For this, the dramatists

---

[1] The theme is similarly treated in *The Castle of Perseverance.* See above, 318. Death appears in the French morality, *Les Blasphémateurs*, (*Répertoire*, 42), and in the Hegge play, *The Slaughter of the Innocents.* For later appearances of Death on the stage see Langlois, 1. 291–307.

[2] See above, 345.

found at hand in ecclesiastical literature of all sorts a fully developed allegory based upon the verse, "Mercy and truth are met together; righteousness and peace have kissed each other."[1] This naturally dramatic theme became the third part of the moral trilogy.

To trace the development of this allegory from the beginning, the student must go to the old rabbinical exegesis of the book of Genesis known as the Bereshith Rabbah, which was compiled and edited in approximately its present form as early as the sixth or eighth century.[2] According to the commentary, God, before the creation, sought counsel of his angels. In the discussion that ensued some favored the creation, others opposed it. "Mercy and truth thrust at one another. Justice and peace fought together." Mercy said, "Create him, because he will practice mercy." Truth objected, "for he will be full of lies." Justice and Peace were likewise of opposite views. God at last threw Truth to the earth (Daniel 8. 12); and the angels who begged that she be allowed to rise, finally left the decision to his judgment.

The story of the dispute in heaven passed from the Midrash into Christian literature, where it was transferred in point of time from the creation to the more suitable period of redemption. In that connection, Hugo of St. Victor introduced the incident in his commentary on the Psalms.[3] Shortly after, Bernard retold the story in more detailed and dramatic fashion in the sermon on the Annunciation already cited as an example of homiletic dialogue.[4] Man, the sermon runs, was originally endowed with four virtues: mercy to guard him, truth to teach him, justice to rule him, and peace to cherish him. But, faring like the man who fell among thieves on his way to Jericho, he lost justice when he listened to the temptations of the serpent, mercy when he burned with carnal desires, truth when he yielded to them, and peace when he gave himself thus to wickedness. But Mercy and Peace, opening the dialogue, beg God to pardon the sinner, and both parties in the dispute are summoned before the judgment seat. Mercy opens the case in court with her plea, and Truth answers, insisting that God's laws be carried out. At this point, Christ, under the name of Solomon, the type of wisdom, is summoned to sit as judge, and Truth continues her argument that the granting of Mercy's request would destroy the

[1] Ps. 85. 10.

[2] Traver, 7–8, 13–14. *Jewish Encyclopedia*, s. v. *Midrash*, and *Bereshith Rabbah*.

[3] *Patr. Lat.*, 177. 621–25.

[4] *Œuvres Complètes*, 3. 340–48. See above, 307.

authority of God. Peace pleads for a reconciliation. Then the judge renders his decision, writing on the ground, "Haec dicit, 'Perii, si Adam non moriatur'; et haec dicit, 'Perii nisi misericordiam consequatur.' Fiat mors bona et habet utraque quod petit." The supporters of both policies are surprised; how can the sinner die and at the same time enjoy mercy? The judge accordingly explains that it can come about only by the voluntary death of some innocent man. But Truth among all the mortals on earth can find no innocent person, while Mercy in heaven can find no one with enough love for man to make the sacrifice. Peace then declares that only God himself can do it, and the plan of redemption is decreed.

It would be beyond the scope of this book to trace the progress of Bernard's dramatic sermon through medieval religious literature. Bonaventura in the *Meditationes*, Robert Grosseteste in the *Chasteau d'Amour*, the author of the *Cursor Mundi*, and many other churchmen in homily, treatise, and poem, copied it either at first hand or indirectly. It descended, therefore, as a heritage to the sacred drama.[1]

Of the ten French plays which contain the dispute, the most complete is Arnould Gréban's *Mystère de la Passion*. After a preface narrating the creation, the fall of Lucifer, and the sin of Adam, the long play opens with a scene in Limbo, where Adam and Eve in company with the prophets wait with lamentation and entreaty for the coming of the Son of God. Then the scene changes to Paradise, where Mercy, Truth, Justice, and Peace are met to determine the fate of man. Their argument hinges mainly on the relative degrees of culpability of Lucifer and of Adam. All agree that Lucifer's crime is unpardonable; but Mercy shows that man sinned not through lust of power, as did Satan, but in ignorant craving for knowledge. Justice, however, declares that both Adam and Lucifer rebelled against God's power. In this opinion Truth, "a woman very wise and prudent," concurs. But Mercy, encouraged by God's reminder of his grace, insists that man's inherent nobility, and his condition of ignorance and weakness at the time of the fall, entitle him to a lenity that Lucifer can not claim. The six grounds on which she bases the distinction convince Justice and Truth that man's punishment should not be eternal; but what should it be? On this point Mercy defers to the deeper wisdom

[1] In her full history of the allegory, Miss Traver discusses ten French plays: Mercadé's, *Mystère de la Passion*, Gréban's *Passion*, *Viel Testament*, *Le Mistère de la Conception*, the Valenciennes *Passion*, *La* Rouen *Incarnation*, *La Vengeance Nostre Seigneur*, *L'Amour Divin*, *La Moralité de Nature*, and *Le Laz d'Amour Divin*. See Traver, 70–124.

of Sapience, who says that man can be redeemed only by his Creator, and that of the members of the Godhead the Son is the fittest for the task.[1] Here the dispute ends. But in a poem of such vast dimensions as Gréban's, this, the central incident, as it is represented, of human history, could not be at this point finally dropped. As Christ prays in the garden that the cup may be taken from him, God begs the four virtues to reopen the case and find some milder form of atonement. Here, though, Justice remains obdurate to Mercy's entreaties, and the original verdict is carried to its fulfillment—the Passion. Finally, after the Resurrection and the Ascension, God summons the sisters for the last time, reviews the cause of the dispute, and gets their admission that full recompense has been rendered by the Son.[2]

Thus the miracle-plays and the Passion plays introduced the allegory as the forerunner of the redemption. It formed the basis, for example, for the pageant of *The Salutation and Conception* in the so-called Coventry cycle. There Contemplacio calls upon God to end speedily for prophet and patriarch the long imprisonment in hell. But against the Father's inclination to forgive, Truth brings objection, and the debate results. Peace effects a reconciliation, and Filius, at her suggestion, offers himself as the required sacrifice.[3]

The debate was adopted also by the authors of the English moral plays, but in a different manner. The miracle-plays accepted the incident as an historical fact, the precursor of the central point in the world's history. The homilists of the moralities, on the contrary, who to an erring humanity held out the hope of salvation, brought the theme forward from its historical setting in the past to the present, in order to exhibit it in its eternal significance. They regarded it not as a single occurrence, but as the ever recurring ordeal that decides the destiny of every mortal man. In this way the English moral play suited the allegory to its purpose.[4]

The dispute between Mercy, Truth, Righteousness, and Peace appears in three extant English moral plays, but only once in its true form. *Respublica* removes it from its true setting, and strips it of its inherent beauty, to render it serviceable in a political drama whose interests were largely secular. In response to Respublica's prayers for help against her civil enemies, Mercy is sent to earth

[1] 1741–3378. [2] 18812 ff. and 34088 ff.

[3] Reprinted by Manly, in part by Pollard, and also in the edition of the cycle.

[4] The three French moralities, which I have not seen, treat it as a separate incident.

to bring relief. The goddess calls her sister, Truth, to her aid, for the two are here to *meet* in full accord rather than in strife, and the evil counselors of the queen, who have been ravaging the kingdom, are exposed. Justice and Peace are then summoned, the one to defend and the other to preserve order, and the four oppressors, Avarice, Adulation, Insolence, and Oppression, are sentenced to punishment.[1] In a second play, *Mankind*, the allegory is indirectly alluded to by Mercy, who assures Mankind that Justice will be abrogated at his trial, and Truth checked in his "streyt argument," and that her counsel will prevail.[2] In the portion of *The Pride of Life* now lost, fuller justice was doubtless done the theme; but only in *The Castle of Perseverance* is it given in full. In that typical morality the triumph of Mercy and Peace, and the release of man's soul from the power of the Devil, close the story of man's career.

Through three great crises, then, the complete English moral play, the so-called full-scope morality, carried the story of man's life and destiny. The earliest crisis, which sprang from the allegory of Prudentius and the early Fathers, formed the foundation for the type; without a moral struggle based on the doctrine of freedom of the will there was no true moral play. But the Middle Ages lived in faith of a future. So, to show the urgent need of warfare against carnal and spiritual vices, the sacred dramatists embodied concretely the sure approach of Death and the fruitless appeals of the soul; to give hope, though, even to the sinner, they displayed by means of this debate in heaven the clemency of God. In this dramatic trilogy the full account of human destiny was embraced; a dramatic narrative of real value in itself as an admonition, but a web also, as it were, into which might be woven the doctrinal teachings regarded as most essential for the common man. None of this matter, however, was original with the drama, or in any sense even new; it was the old, essential story that the church would restate. Yet beyond this familiar material the legitimate moral play could not advance far. To dwell too fully on the nature of the temptation confronting man introduced a coarse

[1] Act 5. See below, 370. We note a somewhat similar secularization of the dispute in the *Colloque Social de Paix, Justice, Miséricorde et Vérité*, which was written, if not played, in 1559 to celebrate the treaty framed by the kings of France and Spain. Peace complains to God that she is being oppressed on earth by Mars. God restores her to her rights. Justice, Mercy, and Truth bring Peace word that Justice and Truth will again prevail. See Holl, 41–42.

[2] 832–35.

realism that soon submerged the ethical purpose of the play. Even the story of the Dance of Death introduced among the abstractions real characters—the king, the queen, and the bishop, in our earliest play—which also would eventually lead to the disintegration of the type. Similar, too, was the trend of the other lines of development that will be discussed in the next chapter. For these reasons the moral play was destined to disappear in the freer spirit and broader knowledge of the Renaissance. But as long as men were moved by allegorical representation of human life, as long as they were satisfied with old religious truths slightly seasoned with the spice of realism, the theme of conflict, extended and diversified by these other contributory allegorical incidents, gave matter sufficient for a popular drama.[1]

Chapter VI.—Plays of the Reformation.

But in the sixteenth century the Revival of Learning brought to England new interests that broadened the mental horizon, reawakened the artistic instinct in literature, and thereby challenged the absolute sway of religion in the world of thought. Henry was the

[1] The French drama admitted a wider range of allegory. The narrative of a pilgrimage along the way of life was given dramatic form in *Bien-Avisé, Mal-Avisé*, one of the most worthy of the French plays, and in other moralities. The theme was doubtless taken by the playwrights from Raoul de Houdan's *Songe d'Enfer* and *Voie de Paradis*, poems of the late thirteenth century; but its ultimate source, of course, is in strictly ecclesiastical literature and the New Testament. Lactantius, in the *Divine Institutes* (Bk. 6, chap. 3), compares the course of human life to the letter Y; for every youth comes to such a fork in his progress, where he must choose to follow either good counselors along the road to salvation or evil advisers along the way to hell. Later writers gave the lesson in allegory. A religious treatise of the thirteenth century, *De Tribus Dietis*, marks out the road from Penitence to Paradise in three relays, or *dietae*, Contrition, Confession, and Satisfaction, in connection with the story of the Prodigal Son (cf. Dante, *Pur.* 9. 94 ff. and Peter Lombard, *Sent.* 4. 16 A.). If the treatise was originally a sermon, as Lecoy de la Marche conjectures (97), we may postulate another direct influence of the pulpit upon the stage. It is strange that this strictly Biblical allegory was not used by the English dramatists. Other themes employed by the French playwrights are not religious at all. *La Condamnation des Banquets* is purely worldly, a tract of the dietarian; *Honneur des Dames* is romantic, showing the influence of the *Roman de la Rose* (see *Répertoire*, 47, 73). Such themes were not known on the English stage.

patron of the New Learning as well as the Defender of the Faith. The change could not but be reflected in the moral play—for the first time with any degree of force in Skelton's long play, *Magnificence*. The author was himself a priest, familiar with the traditions and institutions of the church; but he was also an educator and *littérateur* who lived only a few years before the full glory of the early Renaissance in England. Skelton's play, therefore, combines the old and the new. It retains the form of the typical morality, but in content and style gives evidence of the disintegration of the religious drama in the new currents of thought.[1]

Skelton in this play abandoned the rôle of theologian to take up that of moral adviser; the lesson he teaches is not holiness, but prudence; the end he seeks is not salvation in the world to come, but happiness and prosperity in this. The story tells how King Magnificence is persuaded to cashier Measure for a new adviser, Liberty, and to follow the evil counsel of four base courtiers, Counterfeit Countenance, Crafty Conveyance, Cloaked Collusion, and Courtly Abusion. By them the resources of the country are impaired, and the honor of the king tarnished. Finally, however, the king is reclaimed by four virtues, Good Hope, Redress, Circumspection, and Perseverance. For the material of this ethical-political play Skelton had to look away from the writings of churchmen to those of philosophers and satirists. His sources were twofold—the *Ethics* of Aristotle and the *Narrenschiff* of Brandt. The former he used freely, as it was modified in the English versions of the pseudo-Aristotelian *Secreta Secretorum*, in Occleve's *Regement of Prynces*, or perhaps in Skelton's own *Speculum Principis*. Striking peculiarities of the play are directly traceable, as Ramsay has shown, to these royal handbooks. Skelton's second source, the *Narrenschiff*, had already served as model for his *Bowge of Court*, and he turns to it again in those passages of the play that exhibit the abuses of the court. He found in his source even the names of the four courtiers. But more important still, as Herford has shown, he learned from Brandt to substitute for the allegorical character types of real men and women. *Magnificence*, then, marks the beginning of the break-up of the allegorical drama.[2]

But the drama was not yet to be wholly lost to religion; before its vogue was outlived new need for its service arose. The church

[1] The best study of this play is that of Ramsay, who has edited it for the E.E.T.S. His introduction contains also much matter on the general history of the plays.

[2] Ramsay, Introduction, Pt. 1, sect. 7. Herford, 350–52.

universal, whose doctrines and exhortations it had long been the drama's mission to popularize, was shattered by the great schism of the sixteenth century, and a long religious war was begun between Rome and the reformers. More than ever before, argument and invective entered into ecclesiastical literature. Naturally, the moral play was remodeled to meet the changed conditions. Where it had been before simply the support of religion in general and right living, it now became, without any radical diversion of purpose, a weapon used alike by both parties in the controversy. Despite the innovations of Skelton, therefore, the play remained a while longer the obedient servant of the church, and allegory on the stage was saved from disuse.

The new tendency in its early stage is well exemplified by John Bale's *Three Laws*. As in the miracle-plays, God himself appears; but it is to establish at the beginning the authority of the three Laws, and to restore them, at the close, to their ordained spheres. To these ends the presence of God was at least felt in all true moralities. The other characters are strictly allegorical, and the action involves the familiar struggle between the good and the evil. Indeed, in this play three conflicts instead of one, in three separate episodes, are carried through. God has ordained the Law of Nature, the Law of Moses, and the Law of Christ as his emissaries on earth. But Infidelity corrupts the first through his children, Sodomy and Idolatry; the second, through Avarice and Ambition; the third, through False Doctrine and Hypocrisy. In the action itself, none of the temptation and none of the fruits of sin are exhibited. The three Laws in due order state didactically their mission in the world, the Law of Moses, for example, expounding the Commandments; they are answered by the vices sent to tempt them; finally Infidelity announces their fall. Although the traditions of the morality have been thus altered, *The Three Laws* adheres in the main to the structural and didactic principles of the type. At the end, the powers of evil are overcome and punished by Vindicta Dei, and God restores the Laws to their original power.

Bale, however, while keeping easily within the bounds of tradition, has used the morality for a new purpose—not primarily as a sermon on holiness, but as a weapon in religious controversy. His play is a coarse and bitter attack upon the Papacy. At the end, in reviewing the course of events, the author states that the Laws were corrupted respectively "by the Sodomites, Pharisees, and Papists most wicked." The truth, however, is that his religious bigotry so got the better of his sense of historic truth that all the

evil characters of the play are represented as children of the Roman church. Infidelity upholds the time when men never read the Bible or talked of Paul, and the corrupters of the Law of Moses, declaring that the clergy and the people must be kept in ignorance, frame a new, and supposedly Popish, creed. But Bale directs his attack not primarily against the "draffish ceremonies" of the Roman church, or the political opposition of Reginald Pole to the policies of the admired King Henry; with a coarse vituperation that has never been exceeded, he assails, without much concern for truth, the gross immorality of the Roman priests. This is the new mission that the old-time morality was now given to perform—the new wine poured into the old bottles.

The moral play, however, as it continued its activity in religious controversy, could not long retain unmodified the traditions of the sacred drama. The Reformation was a broad movement which involved political and economic, as well as religious, matters; especially in England, such questions as the disposition of church properties, the reception of Papal legates, the very authority of the King, were made the points at issue. Hence the plays that undertook to support one side or the other were forced to admit a consideration of secular things, where before abstractions had been supreme. Accordingly, the dramatists substituted for the indefinite scene and occasion of the older plays a more definite setting; they surveyed for criticism the policies of real men. In these ways the allegorical drama underwent secularization.

Ramsay has expounded very consistently the historical significance of Skelton's *Magnificence*. Magnificence is in general intended to represent the characteristics and tendencies of King Henry—generous, open-hearted, but susceptible to evil counsel. The six evil advisers who encourage him in his course to ruin embody the traits and policies of Wolsey, whose extravagance emptied the treasury and humbled England abroad. The saner characters represent the leaders of the old nobility, who stood in opposition to the upstart, and Circumspection is supposed to represent King Henry VII. The allegory is by no means manifest; but doubtless the audiences of the time saw readily the political drift of the plot.[1]

By a modification of the type somewhat similar to that already discussed, Bale made his *King John* half morality and half chronicle history. Instead of localizing the plot in the England of his own time, as Skelton did under the cloak of allegory, Bale selected

[1] *Magnificence*, Introduction, Pt. 1, sect. 9.

as an example of the antithesis between good and evil the struggle of King John against the Papacy, exalting the ill-starred king, for the enemies he made, into the champion of right, and typifying in the Pope all the political and religious corruption of his own time. In harmony with this historical setting, real characters take part in the action, and the allegorical personages represent less moral than political concepts. Sedition, Dissimulation, Usurped Power, and Treason, are the emissaries of the Satanic pope, who corrupt Clergy, set Nobility against his sovereign, and weaken Civil Order and Commonalty. Against the wrongs suffered at the hands of Clergy and Nobility, the widow England protests, and wins from the King a promise of assistance, which only the influence of Sedition and Dissimulation over his rebellious nobles renders him impotent to fulfill. He is forced to see his subjects led further into crime, and in the end, opposed by Stephen Langton and the Papal legates, he is excommunicated for his resistance of evil, forced to abdicate, and finally poisoned.

As an exponent of Puritan dogma the play, of course, could not remain true to its historical setting; Bale simply set back the schism of his own day into those troublous times, where he could find suitable types, without modifying at all the character of the Protestant revolt. John brands the church a "hepe of adders of Antechrists generacyon," and exposes boldly the evils that it breeds:

> Than for Englondes cawse I wyll be sumewhat playne.
> Yt is yow, Clargy, that hathe her in dysdayne:
> With yowr Latyne howrs, serymonyes, and popetly playes,
> In her more and more Gods holy worde decayes;
> And them to maynteyn, unresonable ys the spoyle
> Of her londs, her goods, and of her pore chylders toyle.
>
> (413–18)

All this Dissimulation corroborates:

> To wynne the peple, I appoynt yche man his place:
> Sum to syng Latyn, and sum to ducke at grace;
> Sum to go mummyng, and sum to beare the crosse;
> Sum to stowpe downeward as ther heades ware stopt with mosse;
> Sum rede the epystle and gospell at hygh masse;
> Sum syng at the lectorne with long eares lyke an asse.
> . . . . . .
> Of owr suttell dryftes many more poyntes are behynde;
> Yf I tolde you all, we shuld never have an ende.
>
> (697–720)

It was such an organization to which Nobility and Civil Order resigned their independence, and by which poor Commonalty was rendered impotent. In attacking the evil, the bitter controversialist touches upon the political as well as the religious questions involved in England's Reformation, defending the divinely appointed supremacy of kings as well as assailing the power of Rome. King John, then, illustrates the development of the morality during the course of the sixteenth century. Contrast the political personifications of the play with the stereotyped figures of the seven deadly sins; its historical background with the indefinite setting of its predecessors; and the heightened reality of its action with the slow movement of the older play, and one sees at a glance the progress toward the real drama that the morality here made. Bale was the most original, as he was the most vigorous, of the Protestant dramatists of England.[1]

The playwrights may have learned their first lessons in the allegorical treatment of contemporary politics in the preparation of royal pageants. At a "disguising" at court during the visit of Charles V to London in 1523, an unruly horse, intended to typify the French king, was tamed by Amitie, in the interests of the alliance between Charles and Henry.[2] This, the earliest known experiment in the application of dramatic allegory to contemporary affairs, was soon followed by more serious essays. In 1527 the members of Gray's Inn produced John Roo's morality play, which represented Lord Governaunce as ruled by Dissipation and Negligence in a way that seemed to Wolsey unduly personal and disrespectful.[3]

These distinctly political plays were soon followed by others that broached religious issues. In November, 1527, the master of St. Paul's, John Ritwise, had his boys give before the French ambassador a Latin comedy, "the effect wherof was that ye pope was in captiuitie & the church brought vnder the foote, wherfore S. Peter appeared and put the Cardinal in authoritie to bryng the Pope to his libertie and to set vp the church againe".[4] The piece has not been preserved; but the caste included, besides "the herretyke Lewtar" and "Lewtar's wyfe, like a frowe of Spyers in Almayn," and three Germans arrayed in notched clothes, such personifications as Religion, Ecclesia, Veritas, Heresy, and False Interpreta-

[1] A Protestant describes an interlude played in Cranmer's house in 1539 as "one of the best matiers that ever he sawe touching King John" (Chambers, 2. 221). The prologues of Bale's miracle-plays are controversial.

[2] Chambers, 2. 219. [3] Hall, 719. [4] Hall, 735.

tion.[1] Another play was given the next year to represent the release of the Pope.[2]

Even this scanty information concerning these lost Catholic plays shows that the English religious drama must perforce have come into close relationship with Continental influences, especially in Lutheran Germany. The influence that inspired the early moral plays was largely the teaching of the Catholic church—the church universal, whose literature knew no national bounds, and responded to no markedly national trend. The wave of Lutheran reform, however, shattered this unity, and the Protestant writers borrowed not from one general source, but from one another. Hence, especially after Henry VIII's change of policy had driven many reforming clergymen to Germany as exiles, the English drama was subject to national influences that it had never before felt to such a degree.

In Germany, where the Lutheran leaders were humanists as well as reformers, the moral dramatists of the new school found a number of virile writers closely akin to them in spirit and methods. The medieval debate, as has been shown, being a literary exercise in which the thought occupied but an insignificant position, was quite remote from the proper field of the religious drama. But the German humanists of the sixteenth century found that the debate might be more than a literary pastime; that it could be made an effective weapon in their controversy with the old religious order. Erasmus and Hutten learned to handle the weapon most deftly and effectively; but many others in the early sixteenth century gave to this medieval-classical form a new vigor that widened immensely its usefulness.[3]

The polemical dialogue grew under such treatment to qualities really dramatic. Instead of introducing, as of old, antithetical personifications to carry on a perfectly obvious disputation, a greater number of characters, representing real life as well as abstractions, were used. "Not merely the 'rich' and the 'poor,' the priest and knight, the 'Lutheran' and 'Catholic,' but peasants, scholars, nobles, monks, clerks, courtiers, beggars, fools, pedlars, innkeepers, weavers, tailors, Wurst-buben, women and children, young and old, pious and froward, pass across the stage."[4] Inevitably the writers of dialogue sought more and more to give to these varied characters and realistic situations a dramatic value.

The effectiveness of the polemical dialogue did not escape the

[1] Creizenach, 2. 140; Chambers, 2. 219.
[2] Chambers, 2. 220.
[3] Herford, chap. 2, "Polemical Dialogues".
[4] Ibid. 28.

notice of Tyndale and the other English exiles who, especially after Henry's favor was in 1540 turned to persecution, sought refuge in Germany. Soon the critics of Henry's reactionary policy were throwing their arguments into dialogue form. Such controversial pieces circulated without restriction during Edward's reign, and exerted a wide influence until the Marian oppression checked their activity, and the progressive spirit of Elizabeth rendered them unnecessary.

To a certain extent the Catholics used the dialogue to defend their church from its assailants; but not till late in the sixteenth century, and with only half-hearted zeal.[1] More's undramatic dialogue in reply to Tyndale's book on the mass was the one work to reach any degree of excellence. But the Protestants struck with vigor at the points most in controversy, both religious and political. A priest opens one dialogue with a long lament for the death of Mass in Strassburg. His two servants discuss the death-scene, and wind up with a bitter attack on Wolsey and his party. Another dialogue between a Gentleman and a Husbandman gives a picture of the oppression each class suffered from the clergy. Finally, in 1548, William Turner, who had passed a long exile in Germany, issued his *Endightment against Mother Messe*.[2] Two Protestants, Veryte and Knowledge, bring accusations before Wisdom that lead to the arrest of the sorceress, Mother Messe. She is brought before Judge God's Word, where Knowledge presents the indictment, and, in spite of Covetous' defense, obtains against her a verdict of exile.

The breadth of this last-mentioned dialogue, its dramatic possibilities, and its allegorical framework, naturally encouraged the use of the religious drama in the struggle. This incentive was then still further augmented by the actual dramas of controversy that Englishmen came to know on the Continent. The Neo-Latin drama that arose in Holland about 1530 sought to give to Biblical plays a Terentian structure, and at the same time to inject into the historical narrative a considerable amount of contemporary interest.[3] The Protestants eagerly made use of this rejuvenated and extended sacred play to further their cause. The best known drama of this type is Thomas Kirchmayer's *Pammachius*, a Protestant adaptation of the old legend of Antichrist, in which the Pope is represented as the Satanic ruler whose sway is terminated by the triumph of

[1] Herford, 46–48.
[2] Ibid., 65–66.
[3] Chambers, 2. 217.

the Reformation. Similar plays were produced by other reformers in Germany, Holland, and England.[1]

These Neo-Latin plays from Holland and Germany were known to Englishmen, and some of the most important were put into English. Bale translated the *Pammachius*, and the play in some version was produced at Cambridge.[2] Palsgrave translated the *Acolastus* in 1540, and other translators and imitators, among them John Foxe, followed.[3] The English never used the dialogue as freely as did the Germans, but all the evidence indicates that they handled the allegorical drama with vigor and freedom in the religious and political turmoil of the Tudor reigns.

These controversial religious plays in England kept in the main within the bounds of the old morality type. The medieval mind recognized no innate disparity between the allegorical and the real; medieval literature and art placed both in conjunction.[4] Hence the historical characters of the Reformation could easily be introduced side by side with abstractions, and the actual events of the struggle mingled with the imaginary episodes of the moral conflict. We have already seen how one play, *The Three Laws*, held pretty close to the old model, and how another by Bale, *King John*, marked a decided advance toward historical tragedy; the story of the development may here be continued.

The title of Woodes' long and tedious play, *The Conflict of Conscience*, reminds the reader that the original *motif* of our morality was not altogether forgotten when it was diverted from ethical instruction into the swirl of doctrinal controversy. The scene is laid in England just after the restoration of Catholicism, and Hypocrisy, Avarice, and Tyranny are out in search of reformers. They meet a clergyman with a Scottish dialect extremely suggestive of the schismatic; but he readily proves his orthodoxy by a dense ignorance, a contempt for the Testament, and a thorough familiarity with *The Golden Legend*. He informs, however, against a neighbor, Philologus, who is forthwith haled for trial before the Cardinal. There he states his reasons for doubting the primacy of Peter and the whole theory of Apostolic succession, and questions the Cardinal's authority for the doctrine of the real presence, *Hoc est corpus meum*, with a Puritan's readiness in disputation:

---

[1] Herford, 119–29. Creizenach handles the Latin drama (2. 1–181). There are monographs by Cloetta and Bahlmann.

[2] Herford, 129–32. See below.

[3] Herford, Chap. 3.

[4] Schnaase, 1. 1. 96–97.

> You ask me in what sense these words I verify,
> When Christ of the bread said, 'This is my body.'
> For answer herein I ask you this question:
> Were Christ's disciples into salt transformed
> When he said, 'Ye are the salt of the earth every one,'
> Or when the light of the world he them affirmed? (84)

But in spite of his bold avowal of these truths before the hostile court, Philologus is ensnared by the picture of carnal pleasure that Sensual Suggestion exhibits in a mirror. Conscience, Spirit, and Terror seek to restrain him, and a controversy ensues between Conscience and Suggestion which, although reminiscent of the earlier plays, is greatly abbreviated to allow space for the twenty pages and more of exhortation that Theologus and Eusebius address to the sinner. They get him to state the belief that he once held through study of the epistles of Paul and James, and when he mentions the necessity of good works, they hasten to show him on Biblical authority the superiority of faith. It is such Protestant exhortation of the Puritan stamp that finally recalls Philologus from popery, and brings him to a Christian end.[1]

Again in *New Custom* sectarian controversy makes up the bulk of the play. Perverse Doctrine, to be sure, is unexpectedly converted at the end, and becomes Sincere Doctrine; but the conflict has been used only as an occasion for disputation. Perverse Doctrine, the old Popish priest, condemns in strongest terms the new theologians who read and discuss the Testament familiarly and deny the doctrine of transubstantiation. Such a one, Ignorance replies, is New Custom:

> I am sure he hath not been in the realm very many years,
> With a gathered frock, a polled head and a broad hat,
> An unshaved beard, a pale face; and he teacheth that
> All our doings are nought, and hath been many a day.
> He disalloweth our ceremonies and rites, and teacheth another way
> To serve God, than that which we do use.
> . . . . . .
> But he commands the service in English to be read,
> And for the Holy Legend the Bible to put in his stead,
> Every man to look thereon at his list and pleasure,
> Every man to study divinity at his convenient leisure. (163–64)

[1] The plot was suggested by the conversion of Francis Spira, an Italian lawyer who lived in England about the middle of the century (Ward, 1. 138).

All these heresies, in fact, New Custom bluntly avows when he meets the priest upon the stage immediately after this introduction.

> I said that the mass, and such trumpery as that,
> Popery, purgatory, pardons, were flat
> Against God's word and primitive constitution. (171)

On these points they bicker with no apparent evangelistic purpose and without result; the good character is not even set in the stocks, and reenters at once with Light of the Gospel to discuss the Protestant dogma of justification by faith. This Genevan doctor, in fact, upholds against Catholicism the moderate Puritan position of Elizabeth's early reign.[1]

Very similar in spirit and teaching is Wever's *Lusty Juventus*. Good Counsel and Godly Knowledge brand the traditions of the older generation as vain and its teachers as ignorant and false. They teach a truer doctrine, with the result that the Devil is forced to admit that although the older people followed his laws, the younger generation will not, seeking to live instead "as the Scripture teacheth." So Juventus becomes in Hypocrisy's eyes a "New Gospeller," or in his own "an earnest professor of Christ's gospel." Both these Puritan plays were written under the influence of Bishop Bale. The characters Light of the Gospel and Assurance were suggested by Evangelium and Fides Christiana of Bale's *Three Laws*, God's Merciful Promises was derivative from Bale's *God's Promises*, and Hypocrisy from his *Three Laws*.[2]

The Catholic party was not so ready in this form of argument as their aggressive opponents, and of the plays they wrote only

---

[1] There were other anti-Catholic plays. Henry Cheke's *Freewill* was a translation from the Italian of Nigri da Bassano (Schelling, 2. 60). There is record of a play *The Burning of John Huss* (Schelling, 1. 72). Thomas Wylley, a clergyman of Suffolk, in a letter to Cromwell in 1537 wrote: "The most part of the priests of Suffolk will not receive me into their churches to preach . . . since I made a play against the Pope's counselers, Error, Colle Clogger of Conscience, and Incredulity. . . . I have made a play called a Rude Commonalty. I am making of another called the Woman on the Rock, in the fire of faith affyning and a purging in the true purgatory." (*Letters and Papers. Foreign and Domestic. Henry VIII.* 12. 1. 244). A physician of London, named Luke, wrote during Henry's reign the *Enterlude of John Bon & Mast Person*, a dialogue against the doctrine of transubstantiation. These Protestant plays are alluded to in the poem, *A Pore Help* (Strype, *Eccl. Mem.*, 2. 2. 333–39).

[2] Brandl, *Quellen*, lxiv.

one, *Respublica*, has been preserved. In that long and serious play, Avarice ingratiates himself into the favor of Respublica, calling himself Policie, and introduces his three friends, Adulation, Oppression, and Insolence, as Honesty, Reformation, and Authority. Together they oppress People, whose complaints are all in vain; for Respublica is so completely deceived by her evil administrators that she overlooks the wasting of her revenues.[1] Yet Avarice openly boasts of his schemes for blackmail, perjury, and the sale of benefices, and shows how he has long cheated the king of his customs duties, exported wheat and other commodities illegally, depreciated the currency, and wasted the public forests. Of these evil practices People tries to complain, but is driven off by the oppressors.

In the fifth act Mercy comes from God with assurances of redress for poor Respublica. It is an easy matter for Truth, who accompanies Mercy, to disclose the perfidy of the four evil administrators, and for Justice and Peace, the other reformers, to bring them for trial before Nemesis, who represents Queen Mary.[2] Following the suggestion of Mercy and Truth, Nemesis, because of the good service that Adulation might render, places her upon probation, but she commits Insolence and Oppression to custody, and orders that Avarice restore all that he has gained by fraud. Thus a happy state is prepared for Respublica.

The above outline should show that *Respublica* gives very little attention to the theology of the Reformation; People protests only against injustice and oppression, and Nemesis' reforms look only to honest government. In this, *Respublica* owes much to Lindsay's Scottish morality, *Ane Satyre of the Thrie Estaits*. Of the tedious prolixity of this play no mere outline can give any idea. The central character is King Humanity, whose intent it is to rule according to God's will. But three vices, Wantonness, Placebo, and Solace, bring him into the power of Sensuality, and three evil counselors, Flattery, Deceit, and Falsehood, who pose in the guise of Devotion, Discretion, and Wisdom, delude and debauch the "three estates"—the clergy, the nobility, and the commons.[3] Consequently, Good Counsel, who hopes to reform the king, is driven into exile, and

[1] 3. 3. [2] 5. 8, 9.

[3] There is nothing original, as some critics have supposed, in this idea of the disguise of the vices as virtues; the thought was common in medieval homiletics. Gregory the Great, for example, declared that the vices do not present themselves in their naked wickedness, but assume a fairer appearance, cruelty presenting itself as justice, anger as righteous zeal, fear as humility, and so on (*Morals*, 3. 544–46). There-

Truth and Chastity, repudiated alike by all three estates, are set in the stocks. Only Divine Correction is strong enough to overcome the evil advisers, to free the prisoners, and to induce the king to summon Parliament for the redress of grievances.

In the second part of this long play redress is made. There is withal ample room for some reflection of Scotland's religious reform. The ignorance and vice of the clergy, especially of the pardoners, is ruthlessly exposed; steps are taken to expel all lazy, ignorant, and vicious priests, and to abolish the order of nuns; and good clergymen are found, from one of whom the audience is favored with an exemplary sermon on the Passion and Atonement, and with a Protestant version of the Apostles' Creed. But all this is overshadowed by the call for civil reform. The plea of Pauper for justice to himself and his motherless children, and the protests of John Commonwealth, lay bare the corruption of the state. The Parliament is summoned, and passes legislation looking to the establishment of justice for all, the fair rental of lands, the maintenance of an intelligent and moral clergy, and the prohibition of pluralities and other forms of oppression. There is little distinctly Protestant theology in the play, little that is not found in the satires of Heywood and Chaucer; but there is loud protest against economic and political abuses.

Owing to the course taken by the Reformation in England, the English controversial drama necessarily dealt largely with such public questions. The moral play, *Godly Queen Hester*, uses Biblical narrative, after the fashion of the miracle-plays, to enforce the lesson of humility. But the play is near of kin to the political moralities; for in it are plain references to England's sumptuary laws, the abuse of pluralities, the treatment of the Jews, and the political controversies of Tudor times as waged in

> The slanderous reports, the lies that be made,
> The feigned detractions and contumelious,
> The rhymes, the railings so far set abroad,
> Both painted and printed in most shameful wise. (269)

In the report of the troubles between the lords and the Cardinal, to which most space is given, Dr. Grosart has shown that there is much that is suggestive of the career of Wolsey.[1]

---

fore, he continues, we should scrutinize apparent virtues as money-changers examine coins, to see if they be really genuine (l. c., 611; see also *Pastoral Care*, Part 2, chap. 9).

[1] 262–64, 269.

George Wapull followed the example of these plays in his late morality, *The Tyde Taryeth No Man.* But where those plays preached reform on national issues that were the concern of the Court and Parliament, this later play handles civic abuses that fell within the jurisdiction of the aldermen and the Council. The proverb that stands as the title is misinterpreted by the vice, Corage, as an excuse for selfishness and greed, and by it he incites his followers to a covetousness that brings suffering to faithful London tenants, to a greed that drags spendthrift gallants into the toils of usurers, and to a disobedience that hurries young girls into imprudent marriages. The editor of the play pertinently calls attention to the recognition of these abuses by reformers like Stubbes and Lodge. But the means employed by Wapull were those long familiar to the moral dramatist. Christianity is represented as dishonored and enervated by the abuses of the citizens; she complains against the wrongdoers; and eventually is rescued by the intervention of Faithful Few, who represents sound middle-class citizenship and authority.

The fragments that remain of two plays of this same intent[1] may give place in this discussion to the later plays, *The Three Ladies of London*, and *The Three Lords and the Three Ladies of London.* The allegorical characters who appear at the opening of the first of these plays are not markedly different from the characters of other moralities. Dissimulation, Fraud, Usury, and Simony go to London, and there make suit to the three ladies, Love, Conscience, and Lucre. But the play soon introduces civic questions. In their service of Lady Lucre the four inaugurate, or at least contribute to, certain economic evils that England was then burdened with. They connive at the exportation of necessary commodities in exchange for the most frivolous baubles; they raise the rents in London till Englishmen have to crowd into tenements, as the people of France and Flanders do; they incite tradesmen to petty dishonesty, and lawyers to grosser frauds, and in general sow corruption in the state.[2] The movement of the play suggests a great city pageant rather than a morality. The scenes where the three Lords of London, the three Lords of Spain, and the three Lords of Lincoln—all allegorical—respectively offer themselves as suitors to the three Ladies, whom Judge Nemo has reclaimed, are

[1] *Albion Knight*, and *Somebody, Avarice, and Minister.* Both fragments have been reprinted. See Chambers, 2. 461; Brandl, lix.

[2] 278–79, 305–6, 326–44.

pageant-like. The Lords' retainers, their escutcheons, and their display of costume, would be especially suitable in a civic show. The clash between the Lords of London and the Lords of Spain, which clearly typifies the defeat of the Armada and the glory of London, has the statuesque nature of a charade.[1] Here again is a marked departure from the typical religious play.

But already in these two long Elizabethan plays a point has been reached well beyond the heat of the controversy. The plays handle public matters, but without the bitterness of the controversialist; and poor Simplicity's humorous plea for the three absurd reforms apparently travesties such characters as Pauper and John Commonwealth. It is therefore time to close this chapter with a brief account of the attitude of the government toward these plays of reform.[2]

It must not be supposed that Tudor sovereigns let pass unnoticed this interference of the dramatists in the management of church and state; there was the doctrine of the divine right of kings to be maintained. Henry still stood ready to sanction "plays and enterludes for the rebukyng and reproching of vices and the setting forth of vertue," but he soon learned how troublesome those were that meddled with "interpretacions of scripture, contrary to the doctryne set forth or to be set forth by the kynges maiestie."[3] To follow the measures of repression and regulation that were authorized by royal proclamation and act of Parliament is not easy. Plays of one religious stripe were as useful, the different sovereigns felt, as those of the other were obnoxious; Henry at first saw a difference between plays that handled religious affairs and those that bothered with kingship.[4] Discrimination on the part of the rulers was therefore necessary, and evasion, in consequence, was accepted by the players as their privilege. History, then, is not altogether clear.

The first repressive measures of which the records bear trace were taken by Cardinal Wolsey in 1526 to bring to punishment those responsible for the performance at Gray's Inn of John Roo's morality, *Lord Governaunce and Lady Publike-Wele*.[5] Taking it as an attack upon his public policy, Wolsey "in a greate furie sent for the said master Roo, and toke from hym his Coyfe, and sent

[1] 461–75.

[2] Simplicity is one of the few genuinely humorous characters of the morality plays.

[3] 34 and 35 Henry VIII, c. 1. 1543.

[4] Chambers, 2. 220.

[5] Hall, 719.

hym to the Flete, & after he sent for the yong gentlemen, that plaied in the plaie, and them highly rebuked and thretened." So also objection was taken to a play in 1533 that offered "defamation of certain cardinals."[1] But in the same year Wolsey and the Defender of the Faith looked with equanimity upon John Ritwise's play, already referred to, that handled to his discomfiture "the herretyke, Lewtar."[2] It mattered much whose ox was gored.

The most serious agitation was caused in 1537 by the performance at Cambridge of the noted anti-papal play, *Pammachius*. A half dozen letters passed between Bishop Gardiner and Vice-Chancellor Parker in reference to the occurrence, the former reporting that he had heard many protests from the papists, and demanding a rigorous investigation, the latter assuring the bishop that all offensive passages had been omitted in the performance. But the bishop still believed that the play had spoken contemptuously of Lenten fastings, the mass, and, in fact, all ceremonies, although it was wrong to "mok and skorne the direction of ther prince in matier of religion." The official investigation that he ordered brought out no cause for offense; but the play-book that was forwarded to the bishop confirmed his suspicions, and on his order the players were summoned before the college authorities for reprimand and apology.[3]

Nevertheless, at this time Henry seems to have permitted plays that encouraged religious reform.[4] It was not till Cromwell's displacement in 1540 that Henry turned his favor from the reformers. Then the law was passed forbidding plays to meddle with interpretation of Scripture. This of course was repealed by Edward, who himself, it is said, wrote a comedy, *De Meretrice Babylonica*.[5] A later law forbade on the stage any derision of the Book of Common Prayer.[6] But with the coming of Mary to the throne, royal policy was again reversed by a comprehensive proclamation making requisite, as a precaution against "sedition and false rumors," a license for every play.[7] This provision did not altogether forestall trouble[8]; but Elizabeth saw fit to renew it, and no plays were

[1] Chambers, 2. 220. [2] See above, 364.

[3] J. Lamb, *A Collection of Letters, Statutes, and Other Documents from the MS. Library of Corp. Christ. Coll.* London, 1838, 49–57. See above, 367.

[4] Chambers, 2. 220–21.

[5] 1 Edw. VI, c. 12. Also Chambers, 2. 222.

[6] 2 and 3 Edw. VI, c. 1.

[7] Quoted by Hazlitt, *English Drama*, 15–18.

[8] Gildersleeve, 11–12.

to be so sanctioned that handled matters of religion or state. Throughout the whole period the government made determined efforts to prevent objectionable meddling by the stage.

In this chapter the development of the moral play under the stimulus of the Reformation has been outlined. It was no radical innovation to exact of a dramatic type that had long been the support of religion an alliance with one party or the other; for the idea of godliness in the sixteenth century was never free from the taint of partizanship. The moral play, therefore, ceased to be a plain homily, and became argument and invective. The change of purpose widened its scope. In handling public questions the play could no longer confine itself to abstractions; special problems of statecraft and church, and the policies of real leaders, took their place with ethical warning on the stage. The spirit of criticism, the bitterness of invective, the sharp play of satire, entered also into the play. Thus it was given new and broader possibilities than it had before enjoyed, and in the development was warped from the simplicity of its first design. But it still had a serious mission to perform, and, although marred to our eyes by unfairness and coarseness of partizan zeal, these controversial plays represented exactly the religious spirit of their day, just as earlier plays had responded to the serener and clearer purpose of their churchly authors.

Chapter VII.—Plays of the Renaissance.

By the religious controversy of the sixteenth century the morality play was held longer than it otherwise would have been to the service of the church. In the old field new opportunities were offered to a dramatic literature already showing a restiveness under its restrictions. But the call of the Reformation could not wholly exclude the religious dramatists from the broader interests in life and literature that even earlier had come to England with the New Learning. Besides the plays that broached and debated the great public questions of Henry's reign, there were others that spoke the message of Humanism. In so doing they did not altogether forsake the cause of morality; it was possible to exalt the dignity of secular learning as a means to the higher end that the old-time moralities directly reached to attain. It was possible, also, to find instances of the traditional Psychomachia in the walks of life followed by the humanists and their disciples. Here again, therefore, the moral play found an opportunity for rejuvenation and extension.

The earliest, and in many respects the most interesting, of the humanists' plays is *The Nature of the Four Elements*, which was written about the year 1519 to expound "many proper points of philosophy natural, and of divers strange lands, and of divers strange effects and causes." For this schooling the well-tried machinery of the morality worked admirably. A central figure, Humanity, places himself under the tutelage of Natura Naturata and Studious Desire, and listens to their lectures on the nature of the four elements, the size of the earth and its position in the solar system, and the cause of tides and other natural phenomena. Later Experience is introduced by them as a widely traveled scholar to carry on the demonstration of the rotundity of the earth, and to exhibit on a "figure," or globe, "certain points of cosmography" that Humanity should know.

An interested reader can fancy the attention that this geography lesson would draw from the spectators. It would be to them an explorer's tale.

> This sea is called the Great Ocean,
> So great it is that never man
> Could tell it, since the world began,
> Till now, within this twenty years,
> Westward be found new lands,
> That we never heard tell of before this
> By writing nor other means,
> Yet many now have been there;
> And that country is so large of room,
> Much longer than all Christendom,
> Without fable or guile;
> For divers mariners had it tried,
> And sailed straight by the coast side
> Above five thousand mile!
> But what commodities be within,
> No man can tell nor well imagine;
> . . . . . .
> Oh, what a thing had be then,
> If that they that be Englishmen
> Might have been the first of all
> That there should have take possession,
> And made first building and habitation,
> A memory perpetual! (25)

For a play so frankly pedagogic in content and purpose the author thought best to give some justification. Accordingly, the

Messenger in delivering the Prologue acknowledges, with apparent reference to the strictly religious play, that

> It is a common good act to bring
> People from vice. (5)

But religious precept alone he regards insufficient to raise the ignorant man to a knowledge of God's laws:

> Man to know God is a difficulty,
> Except by a mean he himself inure,
> Which is to know God's creatures that be:
> At first them that be of the grossest nature,
> And then to know them that be more pure;
> And so, by little and little ascending,
> To know God's creatures and marvellous working.
> And this wise man at the last shall come to
> The knowledge of God and His high majesty,
> And so to learn to do his duty, and also
> To deserve of His goodness partner to be. (6)

Or, to put it in prose, the exhibition of scientific truth is a direct furtherance of religion.

For this view of the relation between knowledge and godliness the author might have cited volume and page from many an old theological treatise. Prudentius taught that with Adam's sin Satan gained control over man and nature, and wrought in both a sad transformation.[1] Honorius of Autun develops the idea that ignorance is a spiritual darkness comparable to the exile in Babylon, and that wisdom is a light attained by science.[2] In other words, ignorance and sin have a common parentage. Vincent of Beauvais, who gathered in his enormous encyclopedia all the learning of the doctors, declared that, as bodily labor relieves man of the physical necessities that have burdened him since the expulsion from Eden, so knowledge can relieve him of the ignorance that since then has darkened his mind.[3] Alain de Lille fancied the union of body and soul through Arithmetic, Harmony, and Music, and the rise of Nature, Prudence, and Reason to heaven in a car built of the seven liberal arts.[4] If, then, the weakness of man's mind is but another indication of Satan's domination, the clearing away of ignorance must be a step toward God. The author of the *Four Elements*, therefore, is thoroughly orthodox in claiming for his play a place among more strictly religious productions.

[1] *Hamartigenia*, 216 ff.
[2] *Speculum Ecclesiae*, c. 1243.
[3] Mâle, 83–84.
[4] *Anticlaudianus*.

Even though a humanist may have been also enough of a theologian to appreciate all this, that would do little to recommend his instruction to the unlettered audiences of his day. The lessons of the school were no more popular than those of the church. This the author seemed himself to realize, for to the title proper he added the statement: "if ye list, ye may leave out much of the sad matter, . . . and then it [the play] will not be past three-quarters of an hour of length." To ward off dulness he introduces Sensual Appetite to interrupt the lecture of Studious Desire with his merry Wellerism,

> Well hit, quoth Hykman, when that he smote
> His wife on the buttocks with a beer-pot, (15)

and to draw Humanity to the dissipations so familiar to playgoers of the day. Not much, it is true, of the Psychomachia remains; Humanity is one of those easy-going mortals always ready to follow a chance companion. After having listened attentively to the pedagogues, he follows Sensual Appetite to enjoy at the inn a three-course dinner—a term that the taverner fails to understand—and to revel with Nell and Jane. From the supper that he orders, Experience is able to draw him back to his lesson, but only to lose him again before the evening's dancing and song. These scenes justify the term "merry" that the author applies to the play; in fact, instead of bringing to the action a serious moral conflict, they serve only as a sort of counter-irritant to the didactic matter that the uncultured would think "sad."

The change of spirit that marks this dramatic product of the New Learning is further traceable in the admission of Natura Naturata that Sensual Appetite has its place in man's character, and that only its overindulgence is baneful:

> Though it be for thee full necessary
> For thy comfort sometime to satisfy
> Thy sensual appetite,
> Yet it is not convenient for thee
> To put therein thy felicity
> And all thy whole delight. (44–45)

Medieval asceticism here gives way at least a trifle to the sensuous enjoyment of life that the Renaissance revived. This same point is more fully elaborated in the earlier morality, *Nature*, where Sensuality is represented as an indispensable part of man's psychic being, embracing sense-perception and temperate carnal desires. As Brandl has shown, these distinctive features of the play were

plainly derived from Lydgate's *Reson and Sensualyte*, or its Old French original, *Les Échecs Amoureux*.[1] But Medwell, the author of *Nature*, did not subordinate the moral purpose of the play, as did Lydgate, to the end of humanism, and on the whole gives to the new spirit a less generous recognition than did his successor, the author of *The Four Elements*.

Another significant deviation in these humanistic plays from the ecclesiastical pattern is noticeable in the nature of the guide or preceptor chosen for the hero. Instead of Good Angel or Mercy, as of old, it is Natura and Studious Desire in one play, and God's "minister," Lady Nature, with Reason in the other, that point the way to the desired end. The employment of Reason in this office was continued by John Redford in *Wit and Science*, and by the revisers who prepared the play for later audiences.[2]

Redford's play is clothed in the form of romance. Wit, an unproved youth, is courting Science, the only daughter of Reason. Reason is ready to grant his suit if he proves himself worthy of Science, and he counsels the youth to strive hard to win her. But Wit scorns the counsel of his guide, Instruction, and, accompanied only by Study and Diligence, presses forward. Very shortly, though, he is assailed on the road by the giant, Tediousness, and almost killed, and later, after Honest Recreation has played the Good Samaritan, by Idleness. Through her corrupting influence his appearance and manners are so debased that Science, when they meet, does not recognize him, and flees. But Reason, still ready to aid, encourages him to renew his efforts, this time keeping Diligence and Study under the control of Instruction. So escorted, Wit passes safely the haunt of Tediousness, whom Gayley has aptly called the Giant Despair of the moral plays, and is accepted by Science.

The Marriage of Wit and Science revises Redford's version to the improvement of the dramatic structure, but the *motif* itself remains essentially the same. The youth is impatient of his guides, and not till Shame has schooled him is he ready to accept their service and so win his bride. The other modernization, *The Contract of Marriage between Wit and Wisdome*, injects into the plot much of the humorous realism of true comedy. The two soldiers, Snatch and Catch, who return from Flanders singing,

---

[1] xliii–xliv.

[2] I have been unable to see J. Seifert's work on this group of plays, *Wit-und Science-Moralitäten*, Prague, 1892.

> I hath bin told, ben told, in prouerbs old,
> That souldiares suffer both hunger and cold, (25)

and then bind and blindfold Idleness to make him the butt of their pranks; the quest of Constable Search for Idleness, who in the disguise of a ratcatcher consents to help Search cry the proclamation for his own arrest; the trouble between Doll and Lob over the stolen "poredge pot"—these are the prototypes of real comedy.

The romance that distinguishes this group of plays, and indeed the whole allegorical conception of the various branches of knowledge, owes its origin to a contemporary of Prudentius, Martianus Capella. He began his long treatise on the liberal arts with a romance from which the book received its title, *De Nuptiis Philologiae et Mercurii*. According to the story, Mercury, who has fallen in love with Philologia, the highly cultured daughter of an ancient family, persuades the gods in council to make her a goddess and sanction their marriage. The preparations for the wedding, the bride's appearance on the day of the ceremony, the dress and attributes of the seven branches of *trivium* and *quadrivium* that accompany her, are fully described in this curious allegory. The seven matrons are then given an opportunity to deliver each a long discourse on the branch of knowledge she represents. To these treatises medieval scholars attached great value; they treasured the manuscript in their libraries, used it as a text-book in their schools, and freely recommended it to later writers and to the sculptors who carved the figures of the arts and sciences on the portals of the cathedrals.[1]

Although these three plays hark back more or less directly to this *bizarre* product of the fifth century, the direct influence upon the drama of the English humanists came from the Continent. The teachers and patrons of the New Learning who shortly before the middle of the sixteenth century revived in Holland and Germany the comedy of Terence, took a new and professionally inspired interest in the training of youth. In a style not unworthy of their Latin model, they sought to display the temptations that draw youth from the pursuit of knowledge and godliness, and so to combine the intrigue of Roman comedy with Christian example of the fruits of idleness and sin. The *Asotus* of Macropedius, the *Parabell* of Waldis, and the *Acolastus* of Gnapheus, adapt the story of the Prodigal Son to this new end, and other plays, like the *Rebelles* of

[1] Ebert, 1. 483–85; Mâle, 98–112.

Macropedius and the *Studentes* of Stymmelius, follow the same plan.[1] Whatever one may think of *The Four Elements* and *Wit and Science*, it is no far cry from the genuine morality to these that focus upon the particular problems of student life.

The German school-plays were brought to England through the same channels that carried the controversial literature. Manuscript copies of the original texts, for example of the *Studentes*, circulated among the cultured; the *Acolastus* was translated by Palsgrave; and other plays were reproduced with necessary alterations.[2] These Latin comedies did not employ allegory, as the recognized morality did, but they resembled that type so closely in spirit that in England they customarily borrowed the allegorical method. This they could do without sacrificing at all the desired realism, for allegory was no longer confined to theological abstractions uncolored by human life. In *The Nice Wanton*, an adaptation of *Rebelles*, one sees scarcely any distinction between the two allegorical characters, Shame and Iniquity, and their fellows, who supposedly represent real persons Neither the allegorical nor the real at this time was all that it should be, and they met on almost middle ground. The English school-plays, then, are only a specialized form of the broad morality-type.

The Nice Wanton was written during the reign of Edward VI, it may be by Thomas Ingeland. Its plot is extremely simple. A fond mother has two sons and a daughter. The elder son, whom she has brought up strictly, is regular and punctual in his attendance at school, pursues his studies diligently, and quotes the Scriptures with glib, though Pharisaical, fluency. But his brother and sister, used to every indulgence at home, play truant habitually, are known in the neighborhood for idleness and profanity, and soon learn to gamble and riot with evil companions in the public house. In the latter part of the play, a considerable lapse of time being assumed, the girl dies a disgraceful death, the boy is hanged for theft and murder, and the heart-broken mother is kept from taking her life only by the interference of the elder son.

Both *The Nice Wanton* and its model, *Rebelles*, were schoolmasters' pieces intended to enforce the precept, "Spare the rod and spoil the child." In *Rebelles* the mother is made more directly responsible

---

[1] Herford, 152–58. The French play, *L'Enfant Prodigue*, sacrifices instruction for unrefined amusement. See *Répertoire*, 57–59.

[2] Herford, 108, 158–64. Schelling (1. 64) gives an interesting account of Palsgrave's edition of the *Acolastus*.

by forbidding the master the use of corporal punishment, and at the end the pedagogue gains a clearer triumph by being allowed to save the spoiled boys from the gallows and lead them off to receive their long deserved flogging. The moral in both plays is the same:

> Therefore exhort I all parents to be diligent
> In bringing up their children.
> . . . . . .
> O ye children, let your time be well-spent,
> Apply your learning, and your elders obey;
> It will be your profit another day.[1]

The Disobedient Child repeats this warning for parents and children, but with somewhat different intent; the lesson it would teach is prudence and obedience rather than morality. The son will not go to school, and indeed, if the Elizabethan masters were the brutal slave-drivers he describes, no one can blame the boy; but instead of giving himself to vicious pastimes, he marries—and lives to regret it. He has not money enough to support his wife, and is forced to peddle fagots from door to door; discord destroys his glowing illusion of domestic happiness; and the poor fellow is beaten by his wife as severely as the school-teacher could have done. The theme, then, is as proper for true comedy as for the moral play. The Devil, to be sure, survives, from the old caste of characters; and his final reminder that the world is his son, and the flesh his daughter, and that his allurements are covetousness, wrath, pride, lechery, gluttony, envy, and murder, echoes faintly the morality's proper theme. Were it not for these traits, which were kept alive partly through the ethical purpose of the school-drama, *The Disobedient Child* would belong strictly to a history of comedy.[2]

Naturally the humanists brought to the enrichment of the didactic drama new matter and a broader range of ideals. In the school-play, *Misogonus*, for example, whose resemblance to *Acolastus* Brandl has pointed out,[3] the allegorical garb, and all else distinctive of the moral type except the sermonizing, have been set aside. Misogonus is another son gone wrong through parental indulgence, but the lesson is enforced by methods peculiar to real comedy. The scene at the dicing table and the dancing are explicitly handled, and

[1] Cf. the French school-play, *Moralité des Enfans de Maintenant.*

[2] *Youth*, *Lusty Juventus*, and *Hickscorner* are closely related to these school-plays in that they deal with the temptations of youth.

[3] lxxviii–lxxix.

there are a number of truly humorous character-sketches—the loutish countryman, Codrus, Madge Mumblecrust, who stutters, and the fool, Cacurgus. To these essays in real comedy the author adds an episode from the portfolio of romance. A nurse reveals to the heart-broken father the whereabouts of his eldest son, who was hidden away in infancy by his over jealous mother, and the youth is brought back to the home and the inheritance that await him. Naturally, Misogonus, thus disappointed in his expectations, finds it expedient to reform. The moral ending, however, does not obscure the fact that this incident of the finding of a lost son, which the author doubtless derived from the *Menaechmi* or the *Captivi*, makes the *Misogonus* the prototype of those many Elizabethan romantic comedies which end with such a surprise.

Besides giving to the morality a new variety of matter borrowed from classical sources, as well as more homebred incidents such as the humorous spelling-lesson, the garbling of Latin sentences, and the trial scene in local courts, which was so popular in German dialogue,[1] the humanistic impulse offered to the dramatists a broader range of allusion and even a new type of character which hastened the inevitable secularization of the stage. The author of *The Trial of Treasure* introduces his thesis, that the pleasures of the world are transitory, on the twofold authority of James and Diogenes, and throughout the play the testimony of the ancient philosophers is freely adduced. At the end, Time, after introducing himself as Cronos, the god of the Greeks, plays a more important part in enforcing the moral than does God's Visitation. The similar exaltation of Reason over the ordinary Christian virtues, which distinguishes *Nature* and *The Four Elements*, betokens the influence of Aristotle upon medieval thought. This is still more conspicuous in *Magnificence*. From the *Ethics* Skelton derived his conception of magnificence as a compound of munificence and liberality, and his belief that felicity and liberty are not inimical one to the other provided reason be kept in its rightful supremacy. From the same source the English poet borrowed his characters, Measure and Circumspection, to represent regulative faculties of the soul.[2] Schoolmen like Thomas Aquinas had always recognized a Christian value in

[1] See the long spelling-exercise in *Wit and Science*, 152–56 and in *The Four Elements*, 32. In *Misogonus*, 59, is an instance of the garbling of Latin phrases. The trial is found in *Liberality and Prodigality* and in other plays. These incidents were popularized, if not inaugurated, by the humanists.

[2] *Magnificence*, xxxii–xxxviii.

the philosophy of Aristotle; but in this play the honor accorded it springs from the intellectual, rather than from the moral, interests of the time.

The increasing influence of the New Learning upon the sacred drama left its impress upon the literary style of the plays. The coming of conscious art into dramatic composition is easily traceable. In its easy flow of verse and effective handling of dialogue, John Redford's *Wit and Science* gives promise of the future; *Calisto and Melibœa*, though less of a morality, is still more a work of literature. But it is in their lyric parts that the later moralities showed their most decisive advance. The serious plays had trusted exclusively to Latin hymns for their musical effects; later plays were furnished with rude songs in the vernacular; the efforts of the humanists responded to the impulse of the new lyric poetry. A detailed analysis of metrical structure would be beyond the scope of this chapter[1]; it will suffice to refer to the song, Buy a Broom in *The Three Ladies of London*, the two-part song of *Wit and Science*, the four-part song of *Mary Magdalene*, and the successive lyrics of *Tom Tyler*, to illustrate the rise of lyric power in the dramatic poets.

The story of these humanistic plays foretells plainly and unmistakably the disintegration of the moral play in the new and broader dramatic movement of the Elizabethan age. This will be traced somewhat in detail in the next chapter. But just as the satirical political plays were kept from their free development by the call of the Reformation for a continuance of the old type, so these humanistic plays were shackled by the adoption of the story of the Prodigal Son and of the idle pupil as the most suitable material. Otherwise these early English dramatists would have more often remodeled with English setting and English characters the comedies of Plautus and Terence, as the author of *Jack Juggler* did the *Amphitruo* of Plautus. As it was, allegory might give way largely to reality; the indefinite moral struggle might be made more concrete by placing it in the school or home; but the nature of the parable of the Prodigal Son made necessary the retention of the serious didactic spirit of the old religious play.

This fact we see exemplified in the latest and best of English school-plays, Gascoigne's *Glasse of Gouernement*, where allegory has entirely disappeared. Two rich burghers of Antwerp have each

[1] Ramsay gives some attention to the metrical structure of the moral plays (*Magnificence*, li–lxx).

two sons whom they desire to educate together. Accordingly they place them in the keeping of the schoolmaster, Gnomaticus who has been recommended as "a man famous for his learning of woonderfull temperance, and highly esteemed for the diligence and carefull payne which he taketh with his Schollers." The four boys enter the master's home, and begin a course of study in which secular learning plays no exclusive part. Gnomaticus would not "holde in contempt" the instruction they have already received in the comedies of Terence, in Tully's epistles and "offices," and in prosody; for in the "wanton discourses" of Terence are many "morall enstructions"; yet since "the true christian must direct his steppes by the infallible rule of Gods word," these profane authors are to be used only where they "seeme consonant to the holy scriptures." His first lesson, therefore, is a long discourse, called a chapter, on man's duty to God. This is followed shortly by another, expounding in the same way man's duty to king, country, and parents. The younger brothers listen attentively to the instruction, and, in order to master it more thoroughly, turn the precepts into verse, whose "verie terminations and ceasures doe (as it were) serue for places of memorie." But the elder sons find the moral bent of their master extremely distasteful, for they hanker after the life of the university, where besides the "lectures daily read of all the liberall sciences, of all languages, and of all morall discourses," they might have also "choyse company of gallant young gentlemen." But soon in Antwerp, while their younger brothers are engaged in study, they trickily get leave of absence and seek pleasure in the house of the *meretrix* Lamia. Their father, though, hears of this escapade, and the four are forthwith sent to the near-by university of Douay, a newly founded school, where "the roote of euill hath hetherto had least skope, and exercise hath beene (and is) the more streightly obserued." But even in that "pelting towne packed full of poore skollers," the elder sons come to grief; what the parasite Echo has done in Antwerp to ruin them, the faithless servant Ambidexter continues there. While the less gifted younger sons by diligent application rise to positions of honor, one becoming a minister at Geneva, and the other the Palsgrave's secretary, one of the older boys is hanged for robbery in the Palsgrave's court, and the other is whipped in Geneva for fornication.

Gascoigne's play is of extreme interest and importance to the student of the moralities. The author had had a wider experience than that of most religious dramatists, having become

acquainted during his university career with the works of the Continental humanists, and possibly having learned to know their work more intimately while in the service of the Prince of Orange in the Low Countries.[1] He drops the allegorical element of the English sacred drama, and, like the Continental humanists, deals altogether with human types. He abandons, too, the imperfectly constructed verse of his contemporaries, and writes in the style of the Elizabethan *litterateur* a prose that contains marks of incipient Euphuism. He constructs his drama, finally, in acts and scenes, with metrical choruses between the acts. *The Glasse of Gouernement*, indeed, is more advanced in structure and characterization than any other play thus for considered. Yet in framework it resembles *Bien Avisé, Mal Avisé*, one of the oldest and purest of the French moralities, where, instead of a single central figure, as in the English pattern, two contrasted characters convey the moral lesson. One may say, then, that Gascoigne availed himself of all that the new literature had to teach in structure and style, and profited wisely from the richer experience and learning of the Renaissance, without sacrificing any essential element of the English morality except allegory, and none of the essential elements of the Continental religious play. Because their interests thus held them to a serious didactic theme closely akin to that of the typical morality, the English humanists did not abandon as readily as one would expect the dramatic traditions of their past.

Chapter VIII.—Secularization and Disintegration of the Moral Play.

The zeal of the controversial playwrights in upholding the propaganda of their churches, and the concern of the humanists in the welfare of youth, made possible for the time being a partial conformity with the technique and spirit of the moral play. The Reformation and the Renaissance bent, but did not at first break, the line of the drama's development. Yet even the most serious of these propagandists' dramas opened wider the door to tendencies, already felt to a degree, that were inherently destructive to the type. Instead of presenting a general, unlocalized allegory of human life, the controversial play dealt necessarily with the policies of real men, as well as with dogma, and the educational play with the interests of the teacher and the school. The one brought to

[1] Herford, 159.

the drama the affairs of the world, the other the affairs of domestic life and all the wider interests and richer experience of secular learning. Consonant with the extended scope of these late moralities Lupton's *All for Money* presents the three newly-mated associates —Theology, in a "long ancient garment like a Prophet," who survives from the older type of play; Science, the philosopher, who speaks for humanism; and Arte, who bears "certeyne tooles about him of diuers occupations" to represent the business of ordinary life. They meet in perfect harmony, agreeing that

No good order in the lande can be without vs three,

and their lesson is conveyed not through abstract precept, but by "Plainly representing the manners of men and fashion of the world noweadayes." Before the growing power of realism and of learning neither the religious purpose nor the allegorical method of the old play could hold its own.

The universal interest in the manners of men had won for realism a place even in the early and yet serious didactic plays. The godly counselor Mercy of the Macro play, *Mankind*, is a learned moralist whom Mischief finds lamentably "full of predycacyon." Evidently he was dressed as a preacher, for Mankind recognizes him at first sight as one able to give "gostly solace." Be that as it may, he speaks his "mellyfluose doctryne" at great length, sowing liberally with ecclesiastical Latin his homilies on the significance of the Atonement, the value of good works, and the temptations of the World, the Flesh, and the Devil. But the moral tenor of the piece is submerged in the rude banter and the obscene jesting and song of the tavern and the market-place, and the spiritual abstractions are boldly elbowed by types from real life. The author, to be sure, has not given either the vices, Now-a-days, New-gyse, Nought, and Mischief, or his hero, Mankind, Christian names, but all belong clearly to a rural community. When the hero would "eschew ydullness" to please his adviser, he gets his spade, and, like Piers Plowman, sets himself to husbandry. The devil, Tytivillus, and the vices torment him, stealing his seed and hiding obstructions where his spade will strike. Their own status in the neighborhood is not concealed. New-Gyse, himself a horse-thief, having barely escaped the gallows, swaggers in with the broken rope yet about his neck; Now-a-days returns with booty from a church; and Mischief clanks his fetters as he comes to aid in making a village criminal of poor Mankind. Their talk is racy with native idiom and slang, and their songs obscene. Despite the

eventual conversion at the end, the dogma of the moral play has been largely obscured by the spirit of realistic comedy.

More and more boldly, even impudently, the comedy of real life asserted its right first to recognition, then to equality, and finally, under new influences, to independent existence. Even later plays might still profess, as did Fulwel's *Like Will to Like,* to exhibit, "not onely what punishment followeth those that wil rather followe licentious liuing, then to esteeme & followe good councel: and what great benefits and commodities they receiue that apply them vnto vertuous liuing and good exercises"; but the profession rings false. How much respect did Fulwel desire for prosy Virtuous Living as he comes into the company of cutpurses and tipplers with the edifying exclamation, "O gracious God, how wonderful are thy works?" The dramatist is showing the same weariness of piety and the same preference for wickedness that later distinguished Restoration comedy, and his purely perfunctory moral is at once forgotten.

The forms in which this realism appeared in the morality were varied. *Youth* and *Hickscorner*, after the hero of each has deserted Charity for Riot, Pride, and his sister Lechery, become stories of thievery and hanging that merit the title of sixteenth-century *Beggars' Opera.* In *Nature* realism appears in a breezy sketch of London's houses of prostitution, gaming-tables, and the fashions of the gentleman. In *The Life and Death of Mary Magdalene* the fashions of the fine lady, who curses her tailors for the "most bungarliest tailers in this countrie" that her overgarment should set so poorly, and her waist appear no smaller, and who talks of curling irons, hair dyes, perfumery, and the like, attract most attention. The outcome of this growing interest in the world is found on the title-page of *Tom Tyler and His Wife.* With the theological abstractions who acted the earlier plays compare these: Destiny, a sage person; Desire, the vice; Tom Tyler, a labouring man; Strife, Tom Tyler's wife; Sturdy, a gossip; Tipple, an ale-wife; Tom Tayler, an artificer; and Patience, a sage person." Then compare with the seriousness of the earlier plots the bourgeois simplicity and vulgarity of the story of this tradesman who would tame his shrewish, drunken wife.

Here, in fact, the juncture is reached where morality gives place almost entirely to farce. In France, from the very beginning of the sixteenth century, the *sotie* and the *farce* had been cultivated side by side with the *mistère* and the *moralité*; the *Enfants sans souci*, like the *Confrères de la Passion*, obtained their letters patent from

King Charles VI. But in England the representation of comic incidents from the lives of common people in brief, lively, and entirely undidactic spirit, was not inaugurated till John Heywood, writing, it has been proved, under the direct influence of the French farce,[1] told the stories of *John, the Husband*, of *Wit and Folly*, and of the *Four P's*. But when once this type of play was introduced, the days of the morality were numbered, not primarily because of its superior godliness, but rather because of its abstention from the theme most interesting to humanity—human life. The rule of allegory in literature had been long, and its reach wide; it was now compelled to yield to the reawakened sense of the dignity and the wealth of secular thought and secular life.

It will be impossible to trace further the secularization of the moral play without giving some consideration to the forms of dramatic presentation that then prevailed, for these exercised constantly a greater and greater influence upon the plays themselves. The Pater Noster play of ancient York, the earliest known moral play, and the similar plays at Beverley and Lincoln, were presented after the fashion of the great Corpus Christi cycles by the members of regularly incorporated gilds on pageants that moved from one designated playing-place to another. And in a more simple manner other plays, like *Saint John the Evangelist*, were given as a substitute for open-air religious instruction on Sunday afternoons.[2] But none of the moralities that have been preserved belonged in this intimate way to the life of a particular city, or the needs of a certain parish. Apparently they were in the hands of traveling companies, as the so-called Coventry cycle is conjectured to have been, at first under the supervision of the church, if one may judge from the contents of the plays, but soon controlled by strictly professional interests. Beginning, then, on common ground with the miracle-cycles, the record of the presentation of the moral plays, keeping pace with the change of content, carries the student into the field of professional theatricals.

Other plays than *John the Evangelist* were given out-of-doors. The prologue of *The Pride of Life* admonishes the audience to stand still and listen attentively no matter what the weather might be. But these out-door performances were not all arranged by ecclesiastics as a means of Sabbath diversion, for even a play so thoroughly didactic in spirit as *The Castle of Perseverance* was in the hands of

[1] K. Young, *Modern Philology*, 2. 97–124.

[2] See above, 340.

a traveling company that carried it from town to town. Two heralds went ahead to advertise the play that their fellows purposed

> to playe
> þis day seuenenyt, be-fore gou in syth,
> At—on þe grene, in ryall a-ray. (132–34)

One may fancy the interest that this proclamation would arouse, and the crowds that would throng to the green a week later to watch the stage-hands and the players. Although I imagine that this early play was given in a well-restricted territory, possibly a diocese whose bishop encouraged its performance, the first step toward secularization was here taken. The church could not long control a drama that was entrusted to traveling players.

The free performance, however, of *The Castle of Perseverance* was hindered by its scope. Its long and diversified allegory required a more elaborate stage than a troupe of professional actors could readily equip. In the center stood the castle itself as a refuge for Man from the vices—a turret-like structure spanning a narrow passage-way in which stood a bed to conceal Man's Soul. About this castle, allowing sufficient room for s ne of the players, at least, but not for "ouer many stytelerys" (ma s), was dug a ditch, or, where that was impossible, was rigge up some sort of barricade. Just without this circular enclosure five scaffolds provided conspicuous seats for God, Caro, Mundus, Belial, and Covetousness, which would not be too remote from the audience, who stood before the castle.[1]

[1] The staging of *The Castle of Perseverance*, as illustrated in the sketch accompanying the text in the unique manuscript of the play, was apparently common. The King in *The Pride of Life* boasts that his messenger, Mirth, can

> liztly lepe oure þe lake,
> Qwher so euer he go. (269–70)

In *Ane Satyre of Thrie Estaits*, the shrewish wives "stand be the watter syde"; Deceit runs off with the King's strong box "through the water"; the cobbler's wife immodestly "lifts vp hir clais aboue hir waist, & enters in the water"; and John in escaping must "loup the stank, or els fall in it" (1367, 1571, 1383, 2430). It may be that a ditch proved an effective means of keeping back a too eager audience. Even more common was the use of scaffolds upon the stage. The King of Life had his "place" upon the stage, called specifically a "tent," to which he retired, and, drawing the curtain, remained unseen while his queen talked with the bishop (*The Pride of Life*). So, too, a "house" was provided in *Everyman* for Salvation. And in the monumental Scottish play, *Ane Satyre of Thrie Estaits*, the "seats" belonging to Truth and other characters are

It was an easy matter, though, for these traveling actors to simplify the staging of these plays, and to arrange for playing-places remote from the influence of the church, where their liking for realism could have free play. No place could have been more suitable than the inn, which afforded the desired freedom from clerical restraint, and at same time a shelter, when necessary, from the inclement weather that through much of the year would drive the spectators within doors. Consequently the author of *Mankind* let his hero welcome Mercy "to þis house"; later he is supposed to call for the tapster, while New-Gyse orders the hostler to bring a football for their amusement; and the proprietor is the first man appealed to for contributions.[1] The text seems also to imply that the performance took place indoors, for the weather is said to be cold, and one of the characters leaves the stage to go into the "yard"; but circumstances alone would determine whether the play should be given in the courtyard or the hall, and the demands upon the stage-manager were therefore simple enough to permit of either.[2] *Mankind*, apparently, was played on an open platform or in some court, provided with no set properties, and simply connected by a side entrance with the "yard," and by another door with the room to which the devil and the vices retire. The properties were simple. Instead of castles, ditches, and barricades, only common articles that could be easily carried, or even more easily borrowed at each stopping-place, are mentioned—a net for Tytivillus, a spade and a bag of corn for Mankind, a wallet, a flute, and some other trifles for the vices.[3] Such stage-craft was well within the limited resources of a small company traveling in independence of the church or any municipal organization.

How freely these companies of actors could travel in the face of frequently renewed legal prohibitions can not be known, but wherever they played their motive was gain. One of the most interesting passages of *Mankind* concerns its financing.[4] The piece is already half done, and the vices are playing for popular favor, when suddenly the devil Tytivillus, who up to this point has been

several times mentioned. The King's was so high as to be reached by a ladder, and was probably supplied with a curtain, for he is said to "cum fra his chamber" (1942–53, 808, and the stage-directions between parts 1 and 2). Such properties had been used long before on the pageants of the *York Plays*, but they could not be used freely by actors who would aim to travel with the least possible amount of baggage.

[1] 198, 714, 717. [2] 547.

[3] 292, 317, 528, 437–38, 465. [4] 447–487.

cleverly withheld, bawls from behind the scenes, "I com with my leggis vndur me." The curiosity of the crowd, supposedly, is roused to a high pitch, but it is not to be too readily gratified. New-Gyse provokingly declares,

> Now gostly to owur purpos, worschypfull souerence!
> We intende to gather mony,

for

> Ellys þer xall no man hym se.

What the contribution must amount to is not specified. Now-a-days boldly asserts,

> He [Tytivillus] louyth no grotis, nor pens or to-pens:
> Gyf ws rede reyallys [gold pieces], yf ȝe wyll se hys abhomynabull presens.

But New-Gyse, as he tests first "þe goode man of þis house," modifies this demand:

> Not so! ȝe þat mow not pay þe ton, pay þe toþer!

Then after the passing of the hat, Tytivillus enters, "drest like a devil, & with a net in his hand," and at once all fall to badgering the crowd on its stinginess, just as the writer once heard some jugglers on the market-place in Freiburg tease a crowd of frugal Germans whose *pfennige* were not forthcoming. "Lend me a peny," the devil asks of New-Gyse. But the vice answers with a shake of his empty wallet,

> I haue no monay;
> By þe masse, I fayll ij farthyngis of an halpeny;
> ȝyt hade I x^{li} [10 pounds], þis nyght þat was,

and his two fellows confirm his report.

Similar allusions to the levying of contributions are found in other plays.[1] One may therefore assume that, since the generosity of the playgoers would vary directly with their enjoyment, the actors, who worked for no higher end than personal profit, would not long hold to the drama's religious purpose. Hence the theological framework of *Mankind* has been completely covered by the coarsest sort of realism—the new environment of the inn, to which people flocked not for instruction, triumphing completely over the old, the church. For it was no easy matter to win the favor of the tavern-crowd. The prologue of the early play, *The Pride of Life*, was mindful to ask,

[1] *Life and Death of Mary Magdalene*, Prologue.

> Nou beit in pes & beit hende
> & distourbit nozt oure place [stage].

But usually the actors anticipated disturbance. The first speaker of *Wealth and Health* is surprised by the quiet that greets him:

> Why is there no curtesy, now I am come
> I trowe that all the people be dume
> Or els so god helpe me and halydom
> They were almost a sleepe.
> No wordes I harde, nor yet no talking
> No instrument went nor ballattes synging
> What ayles you all thus to syt dreaming
> Of whom take ye care?

The professional spirit of the players and the environment in which the plays were usually given, which thus hastened the downfall of the religious drama, brought with them also important modifications in form that less directly contributed to the process of secularization. The most noticeable of these changes was the greatly reduced length of the later moralities, or moral interludes, as they are often called. *The Castle of Perseverance* has almost four thousand lines and some thirty-five characters, while *The World and the Child*, which attempts to cover virtually the same ground, contains scarcely one thousand lines, and only five parts. The two parts of *Nature* contain together almost three thousand lines, but an interval of perhaps three days intervened between them.[1] Some of the controversial plays were extremely long, notably *Respublica*, and *Ane Satyre of Thrie Estaits*, whose performance before King James lasted nine hours, with only one intermission for refreshment.[2] But the typical morality of the later period was short, arranged to be played by four or five men within a period of an hour or two. To effect such simplification each actor was given two or more parts to play. One actor, for example, took in *New Custom* the parts of Ignorance, Hypocrisy, and Edification; a second, the parts of New Custom, Avarice, and Assurance; a third, the single rôle of Perverse Doctrine; and a fourth, the parts of Light of the Gospel, Cruelty, God's Felicity, and the lines of the Prologue. *The World and the Child* might have been performed by two actors.[3] How great the need for such simplification was, may

[1] 90. [2] Nichol, Introduction, xlv.

[3] See Ramsay, ed. *Magnificence*, cxxxiii, and also Brandl, 33, 46.

be inferred from the frequency with which it is pointed out on the title-pages of the plays. "Fower may Play this Enterlude," precedes the assignment of parts by the printer of *New Custom*, and similar advertisements are found in *Wealth and Health*, *Like Will to Like*, and other plays. Such shortened entertainment was preferred by the audiences—for did not even King Henry find one of Medwell's lost allegories too tedious for endurance[1]; but it was largely the inability of traveling companies to supply the actors and the staging for the long, full-scope moralities, that most effectively caused their abridgment.

Through this curtailment the moralities lost much in scenic effect. The processional features of *Wisdom Who is Christ*, a strictly theological play, are most striking. At one point the Five Wits of the Soul, dressed in "white kertyllys & mantelys, with cheuelers & chappelettis," and singing, "Nigra sum, sed formosa, filiae Jerusalem," lead the march; Anima follows, "as a mayde, in a wyght clothe of golde gyntely purfyled with menyver"; then Wisdom, clothed in a purple robe richly ornamented with gold, and furred with ermine, and finally Mind, Will, and Understanding, "all iij in wyght cloth of golde," bring up the rear. The richness and variety of the costumes, the slow, stately march, and the solemn hymn, gave undoubtedly a splendid scenic effect not dissimilar to the familiar processions in the cathedrals. Only slightly less impressive were the seven followers of Mind in "rede berdis, & lyouns rampaunt on here crestis, & yche a warder in hys honde," the six perjurers who follow Understanding, and the six gallants who accompany Will, each party with trumpets, bagpipes, or other musical instruments. In all there are thirty-eight characters, twentyfour of whom are on the stage at one time. By such scenic display even religious allegory could be made attractive; crowds would come, if not to listen, at least to see. But could Anima, Will, and the rest continue to hold interest when stripped of their splendor? This the professional actor had to determine.[3]

---

[1] Chambers, 2. 201. [2] 36, 41, 46, 58–60.

[3] The costuming of *The Castle of Perseverance* is indicated on the plan accompanying the manuscript. Queen Mary gave order for the delivery of certain theatrical costumes to her servants for a play to be given by "the gentlemen of the chapell." Some of the items were:

> Genus humanum for a gowne purple breges satten vij yardes
> v virgins Cassockes of white breges, satten
> reason, verytie and plentie, every of them vij yardes

Obviously such processional features and such extensive wardrobes would be beyond the means of small-sized troupes entirely dependent upon the generosity of the playgoing public. But there would be no occasion for such elaborate staging as the plays lost their purely allegorical and homiletic content, and approached realism. A gorgeously colored feather gave Vanity in *Liberality and Prodigality* a feeling of assurance that he could be recognized at a glance. Pride appeared in *Nature* with a doublet "on-laced before," a satin stomacher, and a short gown with wide sleeves, wearing his hair "half a wote" below the ears.[1] Such humanized personifications might best appear in the simple costumes of real life. So also a bit of costume for the controversial plays would suffice to differentiate Popish priest from Genevan doctor. But beyond these simple stage-effects the professional actor would not have to go in an age that tended to the representation of real life. Thus the limited resources that hampered the stage, manager furthered the advance of realism at the expense of allegory, just as the necessity for abridgment resulted usually in the sacrifice of the "sad matter" and the retention of the comedy. In every respect, therefore, the then existing condition of the theatrical art rendered inevitable the secularization of the moral plays.

As a final instance of the changed character and purpose of the late moral play, consider the historical development on the stage of the Devil and the Vice. That the dramatic conception of the Devil had its origin in theological literature, rather than in popular tradition, there can be no doubt. Clergy and laity alike had an unshaken confidence in the continued activity in the world of the demoniacal being who sought Job's ruin, and assailed even Christ himself. In the miracle-plays, therefore, he appeared wherever the story demanded his presence—on the pageants, for example, representing the fall of Lucifer, the temptation of Eve, and Doomsday. In the moralities he stood for the source of all evil, man's great enemy, as God was his great friend. Thus the Devil appears at the end of *The Pride of Life* to carry the King's soul to hell; and in *The*

Self-love a Cassocke of rede satten of breges
Skarsitie a womans Cassocke of Russett & satten of Breges

The bad angell iij yardes of Kersey and winges for the good angell and the bad, iij thromd hattes and tenn dosson of Counters and what youe shall lake for the furniture hereof To provide and see them furnished. *Respublica*, xv.

[1] 67.

Castle of Perseverance, together with the World and the Flesh, his constant associates in theological literature, he leads the forces of evil that seek the overthrow of man. In these early plays, the Devil is a serious character, the product of theological thought.[1]

The origin of the Vice as a dramatic character is more a matter of dispute. Cushman believes that the Devil and the Vice are related only as all influences for evil were supposed to emanate from one source; that the Devil was a theological-mythological being, the antithesis of God, while the Vice was an ethical person, the summation of the deadly sins, the antithesis of piety and morality.[2] Eckhardt, on the contrary, argues that the Devil was the immediate, though not the exclusive, source of the conception of the Vice. Between the two views the difference is but slight; for, since the deadly sins were regarded by churchmen as the children of the Devil, both postulate for the Vice, as well as for the Devil, an origin in theological literature. Chambers has supported an entirely different opinion, that relates the vice to the court fool or jester, who would figure first in the farce; but to the present author the Vice seems more directly descendent from the Devil and the deadly sins.

But neither character retained long the marks of its serious, theological origin; the Devil took on human traits, and the Vice became the intimate associate of man. In *Wisdom* Lucifer appears with the attire of a gallant showing beneath his traditional costume, thus combining the attributes of the trio, World, Flesh, and Devil, and immediately lays aside the Satanic garb to tempt man more effectually as a human being.[3] In other plays the Devil discards his black skin, animal's head, tail, horns, and claws, and assumes a more human grotesqueness, a fiery red face and Bardolphian nose. The Vice was still more completely humanized, and soon became a man playing the part of rogue and mischief-maker. In such rôles he seems more closely allied with the fool, because, the author thinks, older influences had waned. If such be the case, both the Devil and the Vice show again how the allegorical was forced to give way to the concrete, and how theological teaching was supplanted on the stage by comedy of manners.

But as one thus traces along these several lines the breakdown of the old type of play under the influence of secular literature and

[1] Cushman, 16. [2] Ibid., 63; Eckhardt, 101 ff.

[3] The Devil of a French play assumes the same disguise under his more usual costume (Cohen, 220–21).

worldly affairs, the inference should not be drawn that the religious allegory was legislated by dramatic managers summarily from the stage, or that patrons of the new play were never edified by the old. *The Contention between Liberality and Prodigality*, which was given before Queen Elizabeth in 1600, synchronously with *Romeo and Juliet*, *Henry IV*, and the *Merchant of Venice*, proves the contrary. In this late survival, the fortunes of Money, first at the hands of Prodigality and his riotous companions, then in the penurious care of Tenacity (Avarice), dull almost as the perfunctory discourses of Vertue and Equity, bring only two scenes of interest. The postilion beating at the tavern door to awake the host and hostess, and the scene in the court-room, opened with boisterous legality by the crier and the clerk—these are interesting bits of real comedy; but the dull didacticism of the play as a whole shows the tenacity with which the morality clung to its existence.

Besides showing that the moral play was never arbitrarily relegated to the literary scrap-heap, this late survival of the type reveals one direction in which the morality spent part of its force. The allegory teaches, instead of spiritual morality, only a single lesson in conduct—prudence and honesty. A majority of the French moralities, a type less clearly defined than in England, restrict themselves to non-religious advice, to the natural, rather than the spiritual, virtues.[1] Such, for example, is the *Condamnation des Banquets*. But this restriction, when found in an English play, is a mark of decadence. That would be our verdict on *The Trial of Treasure*, which exhibits the transiency of earthly wealth. Just and his friend, Sapience, agree that

> Treasures here gotten are uncertain and vain,
> But treasures of the mind do continually remain,
> (275)

while Lust, led by Inclination, gives himself up to Lady Treasure and her brother, Pleasure. Lust and Just naturally come into disagreement, and actually wrestle upon the stage—so low had the holy war degenerated. But instead of a spectacular conversion, the audience was greeted at the end with a warning example. God's Visitation takes from Lust his companion, Pleasure, and Time removes Treasure,

> For like as all things in time their beginning had,
> So must all things in time vanish and fade. (297)

[1] Mortensen, 137.

Then Time returns "with a similitude of dust and rust," all that remains of Lust and Treasure, to prove the impermanence of earthly things.

Such lessons in worldly wisdom, that belong rather to the philosopher than to the preacher, could veer still further from the morality's beaten path by dispensing altogether with allegory for situations and characters belonging strictly to farce. The author of *Thersites*, working on the idea that "the greatest boesters are not the greatest doers," exhibits an arrant braggart, Herod-like in his vanity, terrified by a helpless snail, and sent whimpering behind his mother's skirts by the threats of a single soldier. This modification of the norm resembles the type of play known in France as the *Histoire*, a narrative used to illustrate some particular truth or maxim of conduct.[1] Such dramatic enforcement of homely proverb need not have departed from the old religious type. The late Elizabethan morality, *The Longer Thou Livest the More Fool Thou Art*, was a revision by Wager of some old, full-scope moral play. The hero, Moros, first appears as a mischievous boy, fond of games and boyish pranks and popular songs—"a witlesse Boy, Singing and bellowing like a dawe." For travestying the good lesson that Discipline would teach him, he is whipped several times. Then as he grows older, he leaves his idle pastimes, and, under the guidance of Idleness and Incontinence, gives himself up to gambling and vice. At this period of his life his friends are the papistical advisers, Ignorance and Fortune. Lastly he appears as an old man swearing vengeance on Discipline. But God's Judgment, who oddly addresses the sinner first with the proverb that suggested the title, overcomes him, and Confusion carries him to the Devil. Wager in handling this proverb used the mold of the full-scope play, and wrote in the spirit of the school-dramatists to illustrate the need of discipline in the home and school. He shot his bolt, too, against Catholicism, at a time when Protestantism was in the ascendant, and when the Marian persecution was still fresh in men's minds.[2] All this indicates that such lessons of worldly prudence might have been handled without sacrifice of moral purpose. That this and other plays, therefore, do betray a weakening of religious spirit is proof that the days of the morality were numbered.

To preserve some such vestige of the didactic purpose of the morality as that found in *Thersites*, was second nature even to the direct imitators of Roman comedy. *Calisto and Melibœa*, a play

[1] Mortensen, 127.

[2] 1361, 1512, 10 ff., 1558.

contemporaneous with many true moralities, presents the typical characters of Latin comedy: the hero, Calisto; the parasite, Sempronio; and the bawd, Celestina, from whose plot Melibœa barely escapes. But at the close the father delivers a long exhortation to virtue that would have done credit to the orthodox allegorical dramatic preacher. Still more directly the author of *Jack Juggler* borrowed from Roman comedy, taking from Plautus' *Amphitruo* the complication caused by Sosia's returning home to find, he believes, his double awaiting him. In the English farce, the hero is fooled by his enemy, Jenkin Careaway, gets into trouble in consequence, and is of course beaten by his master. Yet after this rude horse-play comes the moral, to the effect that the world is full of deceit. Even the farce was fain to proffer a moral reason for its being.

More freely, though, than in the classical imitations of the humanists, the elements of the disintegrating moral play merged in the home-bred dramatic products of the time. Two traces of the morality are prominent in *A Merry Knack to Know a Knave.* The Devil is brought into the action to claim the soul of the dying Bailiff of Hexam, and later to play the part of a human being; and an allegorical character, Honesty, serves as the connecting link between the scenes of the two plots. The main plot is historical, a royal romance such as Elizabethans were fond of, telling of King Edgar's love for a maiden, Alfrida, and the faithlessness of the emissary whom he commissioned to do his courting. The second plot is satirical. Faithful Honesty, who has "the knack to know a knave," discloses the dishonesty of various social types. The conny-catcher and the knight of the post in their perjury; the farmer who buys up corn for export, and thus oppresses the poor; the priest who refuses to help the needy; the courtier and king's counselor who uses his office for self-aggrandizement, all are exposed for what they really are. Here, then, we have realistic comedy combined with a typical Elizabethan romance, bearing the marks of Euphuism in its language, and staged by Henslowe—in short, a typical Elizabethan play, preserving still the relics of the morality type.

Similar survivals from the outworn medieval drama persisted in early tragedy. In the old Roman legend of Appius and Virginia one unknown author saw not only "a rare example of the vertue of Chastitie," but also the stuff of which real tragedy is made. He used it mainly to this end, emphasizing at the start the father's premonitions of coming misfortune, the daughter's confidence in her own strength, the tragic close of her life, and the punishment of

the offenders, mingling with these motives, in the heartless Elizabethan way, low comedy and merry songs. Yet the tragedy still bears the vestiges of the earlier native drama. It is the Vice, Haphazard, who conceives the stratagem by which Appius gains his will, and allegorical characters accompany every step in the development of the plot. As Appius before the crime feels misgivings in his heart, Conscience and Justice pass in dumb show across the stage, one holding in his hand a burning lamp, the other a sword. Immediately after, when Appius leaves the stage, both introduce themselves in the stereotyped manner. The agonized father is calmed by Comfort, and at the end punishment is meted out to Appius and Haphazard by Justice and Reward. Some last glimmerings, then, of the moral play are found in regular tragedy.

In another tragedy, *Cambyses*, the allegorical characters prolong the note struck by the political Tudor moralities. The hero is a Tamburlaine who sends to death an unjust judge, orders the heart cut out of a little child before the father's eyes, and then murders first his brother and then his wife. He himself, the victim of an accident, dies a sudden death. But in this tragedy, also, the allegorical characters of the morality appear. Ambidexter, the Vice, prompts the king to his first crimes; Commons' Cry and Commons' Complaint petition the king for redress; Murder and Cruelty are his hired assassins. Even this forerunner of Marlowe and the tragedy of blood preserved the elements of the disintegrated political morality.

With still less loss the determinative features of the typical morality were carried over by Robert Wilson in that interesting comedy, *The Cobler's Prophesie*, which belongs to the group of mythological plays so popular with the boys' companies of the sixteenth century. After the style of Lyly, Wilson brings the story of the corruption of Bœotia and the Grecian gods to English soil. Mars has forsaken his manly prowess under the spell of his faithless wife, Venus, and all ranks of Bœotian society, save only the poor soldiery, have lost their virtue and honesty. Melpomene and Clio lay aside their pens, for no longer are there deeds of heroes to sing. All this evil has been caused by Contempt, who under the disguise of Content—an old motive of the moralities[1]—has debauched Venus, and degraded courtier, scholar, and squire. Here, then, is the Vice of the moral play acting his well-learned part in this mythological story, and with him as servants of Venus go other allegorical characters,

[1] See above, 370.

Nicenes, Dalliance, Jealozie, and Newfangle, the fashion-maker. But this strange tale of Bœotian life is colored to please the London populace. It is a simple cobbler, a character later exalted by Heywood and Rowley, whom Mercury selects to rouse Mars from his apathy. Ralph, it must be confessed, is not altogether a hero; he hides under the bed to escape his irate wife, he is befuddled in the wood by the mocking voice of Echo, and he is too conscious of his prophetic calling. He succeeds, however, in reaching the court of Mars, and rouses the god to war. Bœotia is invaded and conquered, and with the burning of the "cabbin" of Contempt, social order is restored. In short, *The Cobler's Prophesie* is a play combining classical mythology to please the court with a typical Elizabethan appeal to the tradesmen; yet here again, at the end of the century, appear strongly the features of the morality play.

Such survivals of the religious drama in these late composite plays could have no permanence. The moral play in England had enjoyed a long popularity, and, unchallenged by any regularly organized secular drama such as existed in France at the opening of the fifteenth century, had long professed, if it did not actually show, a moral purpose. But in the last years of the sixteenth century didacticism and allegory on the stage had already passed their zenith, and soon succumbed before a type of play more truly dramatic both in substance and form. That fragments of the morality might find temporary lodgment in these farces and actual comedies and tragedies simply postponed, but did not prevent, the total disappearance of the dramatic species. How were either serious or corrupted dramatic homily to compete with the real comedy of *Gammer Gurton's Needle*, or poor Honesty and his ilk with the familiar human characters of Greene and his contemporaries? So the morality disappeared, leaving only a reminiscence behind. The play, *Sir Thomas More*, written about the year 1590, and once attributed to Shakespeare, mentions a half dozen of the old morals, several of which still remain unknown. Falstaff alludes to the "dagger of lath" that the Vice carried, and to the ranting of the hero of *King Cambyses*.[1] Gossip Tattle bears witness to the popularity of the Devil on the stage when she says: "My husband . . . was wont to say, there was no Play, without a Foole, and a Diuell in't; he was for the Diuell still, God blesse him. The Diuell for his money, would hee say, I would faine see the Diuell."[2] But in

[1] *1 Henry IV*, 2. 4. 151, 425.

[2] *Staple of News*, 1'st Intermean.

another comedy Jonson treated the Vice as defunct, and satirized his old-time role.

> That's fifty yeeres agone, and six,
> (When euery great man had his Vice stand by him,
> In his long coat, shaking his wooden dagger),

he wrote, and his conclusion was,

> We must therefore ayme
> At extraordinary subtill ones [Vices], now,
> When we doe send to keepe vs vp in credit.
> Not old *Iniquities*.[3]

The Devil, who passes these strictures on his old companion, the Vice, counted evidently upon the audiences' familiarity with the character, and on their sympathy with the new comedy of manners.

Although the moral play died, leaving behind in regular dramatic literature only these few unimportant allusions, its influence must not be slighted. As the composite plays prove, no barrier ever existed between the old and the new. Elizabethan comedy had its roots in the by-play of the morality; early tragedy, even, might find scenes of pathos and tense interest in the religious play, and learn there the lesson of causality and the doctrine of the freedom of the will that form its basis. Moreover, the theatrical traditions of the Elizabethan age had their origin in the sacred drama. The old methods of organizing the companies, of staging the plays, and of costuming the actors, were carried on by the players of the secular drama. The audiences, too, trained to expect gross anachronism, and the mixture of comedy and tragedy, thought nothing of them in later times. Hence, although the abstractions of the old play were discarded by Elizabethan playwrights, and although allegorized precept gave place to concrete presentation of real life, the debt of the secular drama to the moral play is greater than any tangible evidence can show.

But upon the religious life of the age, for whose advancement the moral play was first devised, there was left no such impress. The dramatists of the late period had been so engrossed with mirth and so neglectful of godliness, that the stage, except possibly in rural neighborhoods where non-professional methods still prevailed in occasional performances, had altogether ceased to be a week-day pulpit. Churchmen themselves really hastened the change by finding other and more naturally effective means of teaching moral-

[3] *Devil is an Ass*, 1. 1. 83–85, 115–18. See also 1. 2. 30; 5. 6.

ity and religion. The sermon was given a new vitality and an extended influence by the Puritan divine; the works of practical piety that spread over England in dumpy little quartos taught every-day holiness; John Florio's translation of Montaigne's essays opened the way for the moral philosopher. The church, accordingly, no longer needed the service of the theater; the theater felt that it had outlived its indenture. There came, therefore, a re-division of labor in the literary world. The drama was given the task of public entertainment, and, at its best, of sound interpretation of life; the church assumed responsibility for the furtherance of godliness through the spoken and written word. The day of the moral play was over.

BIBLIOGRAPHY OF PLAYS.[1]

Brandl, A. Quellen des Weltlichen Dramas in England vor Shakespeare. Strassburg, 1898.

Dodsley, R. A Select Collection of Old English Plays. Revised, W. C. Hazlitt. 15 vols. London, 1874–76.

Early English Dramatists. (E.E.D.) ed. J. S. Farmer. London, 1905 to date.

Gayley, G. M. Representative English Comedies. New York, 1903.

Jahrbuch der Deutschen Shakespeare-Gesellschaft. Berlin, 1864 to date.

The Malone Society Reprints. ed. W. W. Greg. London, 1906 to date.

Manly, J. M. Specimens of Pre-Shaksperean Drama. 2 vols. Boston, 1897.

Materialien zur Kunde des älteren Englischen Dramas. Begründet und herausgegeben von W. Bang. Louvain, 1902 to date.

Pollard, A. W. English Miracle Plays, Moralities, and Interludes. 3'ed ed. Boston, 1898.

The Tudor Facsimile Texts. (T.F.T.) ed. J. S. Farmer. London 1907 to date.

* * *

Albion Knight (a fragment). 1566.
E.E.D. 1906.

All For Money. T. Lupton. 1577.
Halliwell-Phillips. The Literature of the Sixteenth and Seventeenth Centuries Illustrated. London, 1851.
*2. ed. E. Vogel. Jahrb. vol. 40. 1904.

Ane Satyre of the Thrie Estaitis. D. Lyndsay. 1540.
1. ed. D. Laing. Works of Lindsay. 2 vols. Edinburgh, 1871.
*2. ed. F. Hall. Works of Lindsay. E.E.T.S.O.S. No. 37. London, 1865–71.

Appius and Virginia. R. Bower? 1575.
*Dodsley. vol. 4.
E.E.D. 1908.
T.F.T. 1908.

Calisto and Melibœa (comedy) (before 1530).
1. Dodsley. vol. 1.
*2. E.E.D. 1905.
3. Malone Society. 1908.
4. T.F.T. 1909.

[1] This bibliography contains a list of the extant English moral plays, and of the principal editions in which they are accessible. An asterisk denotes the volumes referred to in the footnotes. Dates are approximate.

Cambises. T. Preston, 1569–70.
Hawkins, T. Origin of the English Drama. vol. 1. 3 vols. Oxford, 1773.

The Castle of Perseverance (as early as 1450).
*1. ed. F. Furnivall and A. Pollard. E.E.T.S. London, 1904.
2. T.F.T. 1908.
3. Pollard. A portion of the play.

The Cobler's Prophesie. R. Wilson. 1595.
ed. W. Dibelius. Jahrb. vol. 33. 1897.

The Conflict of Conscience. N. Woodes. 1581.
Dodsley. vol. 6.

The Contention between Liberality and Prodigality.
Dodsley. vol. 8.

The Contract of Mariage between Wit and Wisdome.
1. ed. J. O. Halliwell. Old Shakespeare Society. London, 1846.
*2. E.E.D. 1908.

The Disobedient Child. T. Ingeland. 1570.
1. Dodsley. vol. 2.
*2. E.E.D. 1905.
3. T.F.T. 1908.

The Nature of the Four Elements. J. Rastell. c. 1517.
1. Dodsley. vol. 1.
2. ed. J. Fischer. Marburger Studien. Marburg, 1903.
*3. E.E.D. 1905.
4. T.F.T. 1908.

Freewill. Henry Cheke (trans.). 1561. (Not examined.)

The Glasse of Gouernement. R. Gascoigne. 1575.
The Complete Poems of George Gascoigne. vol. 2. ed. W. C. Hazlitt. 2 vols. London, 1870.

Godly Queen Hester.
1. Ed. J. P. Collier. Illustrations of Early English Popular Literature. London, 1863.
2. ed. A. B. Grosart. Miscellanies of the Fuller Worthies Library. London, 1873.
*3. Materialien zur Kunde. 1904.
*4. E.E.D. 1906.

Hickscorner. c. 1510.
1. Dodsley. vol. 1.
2. Manly. vol. 1.
*3. E.E.D. 1905.
4. T.F.T. 1908.

Impatient Poverty. 1560.
1. E.E.D. 1907.
2. T.F.T. 1907.

Jack Juggler. c. 1553.

1. Dodsley. vol. 2.
*2. E.E.D. 1906.

John the Evangelist.
See Saint John the Evangelist.

King Darius. Revised, c. 1565.
*1. Brandl.
2. E.E.D. 1906.
3. T.F.T. 1907.

King John. J. Bale. c. 1540.
*1. Manly. vol. 1.
2. E.E.D. 1907.

The Life and Repentaunce of Marie Magdalene. Lewis Wager. 1567.
*1. ed. F. I. Carpenter. Chicago, 1904.
2. T.F.T. 1908.

Like Will to Like, Quoth the Devil to the Collier. U. Fulwell. pr. 1568.
1. Dodsley. vol. 3.
*2. E.E.D. 1906.
3. T.F.T. 1909.

The Longer Thou Livest, the More Fool Thou Art. W. Wager. pr. 1570.
ed. A. Brandl. Jahrb. vol. 36. 1900.

Lusty Juventus. (Reign of Henry VIII.)
1. Dodsley. vol. 2.
*2. E.E.D. 1905.
3. T.F.T. 1907.

Magnificence. J. Skelton. 1515.
1. ed. A. Dyce. Poetical Works of Skelton. 3 vols. Boston and New York, 1862.
*2. ed. R. L. Ramsay. E.E.T.S. London, 1908.

Mankind. Before 1483. (Schelling, 1.56, n.)
1. Manly, vol. 1.
2. Brandl.
*3. ed. F. Furnivall and A. Pollard. E.E.T.S. London, 1904.
4. E.E.D. 1907.
5. T.F.T. 1907.

The Marriage of Wit and Science. 1569.
*1. Dodsley. vol. 2.
2. E.E.D. 1908.
3. T.F.T. 1909.

Mary Magdalene.
1. ed. T. Sharp. Digby Mysteries. London, 1835.
*2. ed. F. Furnivall. New Shakespeare Society. London, 1882.

A Merry Knack to Know a Knave. 1592.
Dodsley. vol. 6.

Mind, Will, and Understanding. See Wisdom Who Is Christ.

Misogonus. 1560.
1. Brandl.

*2. E.E.D. 1906.

Mundus et Infans. See The World and the Child.

Nature. H. Medwell. 1486–1500.

*1. Brandl.

2. E.E.D. 1907.

3. T.F.T. 1908.

New Custom. pr. 1573.

*1. Dodsley. vol. 3.

2. E.E.D. 1906.

3. T.F.T. 1908.

Nice Wanton. 1560.

1. Dodsley. vol. 2.

2. Manly. vol. 1.

*3. E.E.D. 1905.

4. T.F.T. 1909.

The Play of the Sacrament (miracle-play).

1. ed. W. Stokes. Transactions of the Philological Society. London, 1860–61. Appendix.

2. Manly. vol. 1.

The Pride of Life (a fragment). 1400?

*1. Brandl.

2. ed. O. Waterhouse. E.E.T.S. London, 1909.

Respublica. 1553.

*1. Brandl.

2. ed. L. A. Magnus. E.E.T.S. London, 1905. (The best critical edition.)

3. E.E.D. 1907.

4. T.F.T. 1908.

Saint John the Evangelist.

1. Malone Society. 1907.

*2. E.E.D. 1907.

3. T.F.T. 1907.

Somebody, Avarice, and Minister (a fragment).

Maitland, S. R. A List of Some of the Early Printed Books in the Archi-episcopal Library at Lambeth. London, 1843. (Not examined.)

The Summoning of Everyman. pr. 1509–30.

1. Dodsley. vol. 1.

2. ed. W. W. Greg. Materialien zur Kunde. 1909.

*3. E.E.D. 1905.

The Three Ladies of London. 1584.

Dodsley, vol. 6.

A Comedy Concerning Three Laws. J. Bale. pr. 1538.

1. ed. A. Schröer. Anglia. vol. 5. 1882.

*2. E.E.D. 1907.

3. T.F.T. 1908.

The Three Lords and the Three Ladies of London. 1590.
Dodsley. vol. 6.
The Tide Tarrieth No Man. G. Wapull. pr. 1578.
ed. E. Rühl. Jahrb. vol. 43. 1907.
Tom Tiler and His Wife. 1540.
1. ed. F. E. Schelling. Publ. of Mod. Lang. Assoc. of America. vol. 15. 1900.
*2. E.E.D. 1906.
The Trial of Treasure.
1. Dodsley. vol. 3.
2. E.E.D. 1906.
3. T.F.T. 1908.
Wealth and Health.
*1. E.E.D. 1907.
2. T.F.T. 1907–8.
3. ed. P. Simpson. Malone Society. 1907.
4. ed. F. Holthausen. Festschrift der Universität Kiel. 1908.
Wisdom Who Is Christ (before 1512).
*1. ed. F. Furnivall and A. Pollard. E.E.T.S. London, 1904.
2. T.F.T. 1907.
Wit and Science. John Redford. 1540.
1. ed. J. O. Halliwell-Phillips. Old Shakespeare Society. London, 1848.
2. Manly. vol. 1.
*3. E.E.D. 1907.
4. T.F.T. 1908.
The World and the Child. pr. 1522.
1. Dodsley. vol. 1.
2. Manly. vol. 1.
*3. E.E.D. 1905.
The Enterlude of Youth. 1500—1525.
1. Dodsley. vol. 2.
2. ed. W. Bang and R. B. McKerrow. Materialien zur Kunde. 1905.
*3. E.E D. 1906.
4. T.F.T. 1908.

BIBLIOGRAPHY.

Ælfric. Sermones Catholici, or Homilies. ed. B. Thorpe. 2 vols. London, 1844–46.

Alain de Lille. Anticlaudianus, et Liber de Planctu Naturae. In The Anglo-Latin Satirical Poets and Epigrammatists of the Twelfth Century. 2. 268–522. ed. T. Wright. Rolls Series. 2 vols. London, 1872.

—— Opera Omnia. Patr. Lat. vol. 210.

Ancien Théâtre François. ed. Viollet Le Duc. 10 vols. Paris, 1854–57.

Antichrist. Ludus de Antichristo. ed. W. Meyer. Sitzungsberichte der Philos.-Philol. u. Hist. Classe der K. Bayer. Akad. der Wissenschaften zu München. München, 1882.

—— The Same. Patr. Lat. vol. 213.

—— The Advent of Antichrist. A Miracle Play. In Five Miracle Plays. ed. J. P. Collier. London, 1836.

— Des Entkrist Vasnacht. In Fastnachtspiele aus dem Fünfzehnten Jahrhundert. Bibliothek des Litterarischen Vereins in Stuttgart. vol. 29, no. 68, pp. 593–608. Stuttgart, 1853.

—— De Antichristo. Adso. Patr. Lat. vol. 101, 1289–98.

Apocryphal Gospels, Acts, and Revelations. Trans. A. Walker. Ante-Nicene Libr. Edinburgh, 1870.

Apuleius, L. Works . . . A New Translation. London, 1889.

Bahlmann, L. D. Die Erneuerer des Antiken Dramas und Ihre Ersten Dramatischen Versuche, 1314–1478. Münster, 1896.

—— Die Lateinischen Dramen, . . . 1480–1550. Münster, 1893.

La Bataille de Karesme et de Charnage. In Fabliaux et Contes. 4. 80–99. ed. E. Barbazan. 4 vols. Paris, 1808.

Blickling Homilies of the Tenth Century, The. ed. R. Morris. E.E.T.S. London, 1874–80.

Bonaventura. Opera. 12 vols. Venice, 1756.

Bourgain, L. La Chaire Française au XIIe Siècle. Paris, 1879.

Bousset, W. Der Antichrist in der Überlieferung des Judentums, des Neuen Testaments, und der Alten Kirche. Göttingen, 1895.

—— The Antichrist Legend: a Chapter in Christian and Jewish Folklore. Trans. A. H. Keane. London, 1896.

Bozon, N. Les Contes Moralisés. ed. L. T. Smith and P. Meyer. Paris, 1889.

Brandl, A. Quellen des Weltlichen Dramas in England vor Shakespeare. Strassburg, 1898.

Chester Plays. ed. T. Wright. Old Shakespeare Society. 2 vols. London, 1843–47.

Chrysostom. Eclogae ex Diversis Homiliis. Patr. Gr. vol. 65.

Cloetta, W. Beiträge zur Litteraturgeschichte des Mittelalters und der Renaissance. Halle, 1890–92.

Cohen, G. Histoire de la Mise en Scène dans le Théâtre Religieux Français du Moyen Age. Paris, 1906.

Conflictus Veris et Hiemis. In Poetae Latini Minores. 598–602. ed. N. E. Lemaire. 2 vols. Paris, 1824.

Cook, A. S. A Remote Analogue to the Miracle Play. Journal of Germanic Philology, 4. 421–51.

Coventry Plays. The Ludus Coventriae. ed. J. O. Halliwell-Phillips. Old Shakespeare Society. London, 1841.

Crane, T. F. See Jacques de Vitry.

Creizenach, W. Geschichte des Neueren Dramas. 4 vols. 1893–1909.

Cruttwell, C. T. A Literary History of Early Christianity. 2 vols. New York, 1893.

Cushman, L. W. The Devil and the Vice in English Dramatic Literature before Shakespeare. Halle, 1900.

Cyprian, T. C. Writings. Trans. R. E. Wallis. Ante-Nicene Libr. 2 vols. Edinburgh, 1868–69.

Dargan, E. C. A History of Preaching. New York, 1905.

Débat du Corps et de L'Ame. In Ancien Théâtre François. 3. 325–36.

Débat du Denier et de la Bubis. In Nouveau Recueil de Contes, Dits, Fabliaux. 2. 264–72. ed. A Jubinal. 2 vols. Paris, 1839–42.

Débat du Juif et du Chrétien. See Hist. Litt de la France. 23. 216.

Débat de l'Yver et de l'Esté. In Recueil de Poésies Françoises. ed. A. Montaiglon and J. Rothschild. 10. 41–53. 13 vols. Paris, 1855–78.

Debate of the Body and the Soul. In A Middle English Reader. ed. O. F. Emerson. New York, 1905.

Debate of the Carpenter's Tools Der Streit der Zimmermannswerkzeuge. ed. M. Müller. Erlangen, 1899.

Debate and Stryfe betwene Somer and Wynter. In Occasional Fac-simile Reprints. No. 12. ed. E. W. Ashbee. 2 vols. London, 1866–71.

De La Desputoison de la Sinagogue et de Sainte Église. In Mystères Inédits du Quinzième Siècle. 2. 404–08. ed. A. Jubinal. 2 vols. Paris, 1837.

La Desputoison du Vin et de l'Iaue. In Nouveau Recueil de Contes, Dits, Fabliaux. 1. 293–311. Ed. A. Jubinal. 2 vols. Paris, 1839.

Dreger, E. Über die dem Menschen Feindlichen Allegorischen Figuren auf der Moralitätenbühne Frankreichs. Göttingen, 1904.

Ebert, A. Allgemeine Geschichte der Literatur des Mittelalters im Abendlande. 3 vols. Leipzig, 1874–87.

Eckhardt, E. Die Lustige Person im Älteren Englischen Drama (bis 1642). Palaestra XVII. Berlin, 1902.

Enfans de Maintenant, Moralité des. In Ancien Théâtre François. 3. 1–86.

Ephraem, the Syrian. Opera Omnia. ed. J. S. Assemani. 6 vols. Rome, 1732–46.

Étienne de Besançon. An Alphabet of Tales. An English Fifteenth Century Translation of the Alphabetum Narrationum. ed. M. M. Banks. 2 vols. E.E.T.S. London, 1904–05.

Étienne de Bourbon. Anecdotes Historiques, Légendes et Apologues. ed. A. Lecoy de la Marche. Paris, 1877.

Felton, J. Robert Grosseteste. Freiburg, 1887.

Fiset, F. Das Altfranzösische Jeu-Parti. Erlangen, 1904. Also in Romanische Forschungen, 19. 407–544.

Gildersleeve, V. C. Government Regulation of the Elizabethan Drama. Columbia University Studies in English. New York, 1908.

Goedeke, K. Every-man, Homulus und Hekastus. Hanover, 1865.

Gréban, A. Le Mystère de la Passion. ed. G. Paris and G. Raynaud. Paris, 1878.

Gregory, the Great. Morals on the Book of Job. 3 vols. Oxford, 1844–50.

—— S. Gregory on the Pastoral Charge. Trans. H. R. Bramley. Oxford, 1874.

Gröber, G. Grundriss der Romanischen Philologie. 2 vols. in 4. Strassburg, 1897–1906.

Guibert de Nogent. Quo Ordine Sermo Fieri Debeat. Patr. Lat. 156. 21–32.

Guillaume le Clerc. Le Besant de Dieu. ed. E. Martin. Halle, 1869.

Guillaume de Guileville. The Pilgrimage of the Life of Man. Trans. J. Lydgate. ed. F. J. Furnivall. E.E.T.S. London, 1899–1904.

Hall, E. Chronicle. London, 1809.

Herford, C. H. Studies in the Literary Relations of England and Germany in the Sixteenth Century. Cambridge, 1886.

Hering, H. Die Lehre von der Predigt. Berlin, 1905.

Hervieux, A. L. Les Fabulistes Latins depuis le Siècle d'Auguste jusqu'à la Fin du Moyen Age. 5 vols. Paris, 1883–99.

Heywood, J. Dramatic Writings. ed. J. S. Farmer. 3 vols. London, 1905.

Holl, F. Das Politische und Religiöse Tendenz-Drama des 16. Jahrhunderts in Frankreich. Erlangen u. Leipzig, 1903.

Honorius of Autun. Speculum Ecclesiae. Patr. Lat. 172. 813–1108

Humbertus de Romanis. De Eruditione Praedicatorum. In Maxima Bibliotheca Veterum Patrum. vol. 25. 424–567. Logdvin, 1577.

Huon de Mery. Li Tornoiemenz Antecrit. ed. G. Wimmer. Marburg, 1888.

Jacques de Vitry. Exempla, or Illustrative Stories from the Sermones Vulgares. ed. T. F. Crane. London, 1890.

Jantzen, H. Geschichte des Deutschen Streitgedichtes im Mittelalter. Breslau, 1896.

Jessopp, A. The Coming of the Friars. New York, 1889.

Jewish Encyclopædia. 12 vols. New York, 1901–06.

Lactantius, L. Works. Trans. W. Fletcher. Ante-Nicene Libr. 2 vols. Edinburgh, 1871.

Langland, W. The Vision Concerning Piers the Plowman. ed. W. W. Skeat. Oxford, 1891.

Langlois, E. H. Essai Historique, Philosophique, et Pittoresque sur les Danses des Morts. 2 vols. Rouen, 1851.

Leach, A. F. Some English Plays and Players. In The Furnivall Miscellany, 205–34. Oxford, 1901.

Lecoy de la Marche, A. La Chaire Française au Moyen Age. Paris, 1886.

Lemaire, N. Poetae Latini Minores. 2 vols. Paris, 1824.

Lenient, C. La Satire en France au Moyen Age. Paris, 1883.

Lester, J. A. Some Franco-Scottish Influences on the Early English Drama. In Haverford Essays, Studies in Modern Literature. 129–52. Haverford, 1909.

Lydgate, J. Assembly of Gods. ed. O. L. Triggs. E.E.T.S. London, 1906.

Lyndwood, W. Provinciale, seu Constitutiones Angliae. . . . Cui Adjiciuntur Constitutiones Legatinae. Oxford, 1679.

Mâle, É. L'Art Religieux du XIIIe Siècle en France. nouv. edit. Paris, 1902.

—— L'Art Religieux de la Fin du Moyen Age en France. Paris, 1908.

Manitius, M. Geschichte der Christlich-Lateinischen Poesie bis zur Mitte des 8. Jahrhunderts. Stuttgart, 1891.

Mansi, G. D. Sacrorum Conciliorum Nova et Amplissima Collectio. Florence, 1759–98.

Marguet Convertie. In Nouveau Recueil de Contes, Dits, Fabliaux. 1. 317–26. ed. A. Jubinal. Paris, 1839.

Martianus Capella. De Nuptiis Philologiae et Mercurii. In Martianus Capella. Franciscus Eyssenhardt recensuit. Leipzig, 1866.

Myrc, J. Instructions for Parish Priests. ed. E. Peacock. E.E.T.S. London, 1868.

Mortensen, J. Le Théâtre Français au Moyen Age. Paris, 1903.

Neale, J. M. Mediæval Preachers and Mediæval Preaching. London, 1856.

Original Ordinances of Early English Gilds. ed. T. Smith. E.E.T.S. London, 1870.

Paris, G. La Littérature Française au Moyen Age. 3'ed ed. Paris, 1905.

Patrologiae Cursus Completus. Series Latina. ed. J. P. Migne. 221 vols. Paris, 1844–65.

The same. Series Graeca. ed. J. P. Migne. 161 vols. Paris, 1857–66.

Perry, G. G. The Life and Times of Robert Grosseteste. London, 1871.

Petit de Julleville, L. Répertoire du Théâtre Comique en France au Moyen Age. Paris, 1886.

Philo Judaeus. Works. Trans. C. D. Yonge. 3 vols. London, 1855.

Prudentius, A. Aurelii Prudentii Clementis Quae Exstant Carmina. ed. A. Dressel. Leipzig, 1860.

Realencyklopädie für Protestantische Theologie und Kirche. Leipzig, 1896 to date.

Religious Pieces in Prose and Verse. ed. G. G. Perry. E.E.T.S. London, 1867.

Rich, E. The Mirror of Saint Edmund. In Religious Pieces in Prose and Verse. 15–48.

Richard Rolle of Hampole. English Prose Treatises. ed. G. G. Perry. E.E.T.S. London, 1866.

Rutebeuf. Œuvres Complètes. ed. A. Jubinal. 3 vols. Paris, 1874–5.

Schelling, F. Elizabethan Drama, 1558–1642. 2 vols. Boston and New York, 1908.

Schnaase, C. Geschichte der Bildenden Künste. 7 vols. Düsseldorf, 1843–64.

Seelmann, W. Die Totentänze des Mittelalters. Norden u. Leipzig, 1893.

Sepet, M. Les Prophètes du Christ. In Bibliothèque de l'École des Chartres. 6'th Series, 3. 1–27, 210–64; 4. 105–39, 261–93; 13. 397–443 (1867, 1868, 1877).

Stevenson, F. Robert Grosseteste, Bishop of Lincoln. London, 1899.

Tertullian, Q. S. F. Writings. Trans. S. Thelwall, P. Holmes, and R. E. Wallis. 3 vols. Ante-Nicene Libr. Edinburgh, 1869–70.

Theodulf, Bishop of Orleans. Opera Omnia. Patr. Lat. 105.

Traver, H. The Four Daughters of God. Bryn Mawr College Monographs. Bryn Mawr, 1907.

Trevelyan, G. M. England in the Age of Wycliffe. New York, 1899.

Trouvères Belges (Nouvelle Série). ed. A. Scheler. Louvain, 1879.

Vices and Virtues, Being a Soul's Confession. ed. F. Holthausen. E.E.T.S. London, 1888.

Wadstein, E. Die Eschatologische Ideengruppe: Antichrist—Weltsabbat. —Weltende und Weltgericht. In Zeitschrift für Wissenschaftliche Theologie. 39. 79–157. 1896.

Walsh, J. J. The Thirteenth, Greatest of Centuries. New York, 1908.

Ward, A. W. A History of English Dramatic Literature. 3 vols. London, 1899.

York Plays. ed. L. T. Smith. Oxford, 1885.

York Records. Extracts from the Municipal Records of the City of York during the Reigns of Edward IV, Edward V, and Richard III. ed. R. Davies. London, 1845.

Young, K. The Influence of the French Farce upon the Plays of John Heywood. In Modern Philology, 2. 97–124.

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 14, PAGES 415-466. APRIL, 1910

The Accentual Cursus in Byzantine Greek Prose

with

Especial Reference to Procopius of Cæsarea

BY

HENRY BRONSON DEWING, Ph.D.

PUBLISHED UNDER THE AUSPICES OF

YALE UNIVERSITY

NEW HAVEN, CONNECTICUT

1910

WEIMAR : PRINTED BY R. WAGNER SOHN

The suggestion which paved the way for the discovery of the Cursus Law in Byzantine Greek prose was made by P. Edmond Bouvy, Poètes et Mélodes. Études sur les origines du rhythme tonique dans l'hymnographie de l'Église Grecque; Nîmes 1886. Bouvy, while searching in the dark for a law which would account for the characteristic rhythm of the Greek prose of the Byzantine period, noticed the common occurrence of an accentual dactyl at the close of sentence members; that is, such words as *ἄνθρωπος, ἐλελύκεσαν* often stand in this position. This seemed to him to be the essential characteristic of the language in question, and he suggested that a final accentual dactyl should be considered the fundamental element in the clausulæ of the rhythmical prose of writers from the fourth century on. He noticed further the striking circumstance that in a large number of cases the final accentual dactyl is preceded by another accentual dactyl, making altogether an accentual dactylic dipody.

Wilhelm Meyer saw that the suggested law of the final accentual dactyl offered no satisfactory solution, simply because not a single writer could be found whose language followed such a law with any regularity. But the incidental observation made by Bouvy that the final accentual dactyl was often preceded by another suggested to Meyer that the first dactyl, and not the final one was the essential factor. It was soon apparent that he had the key to the situation, and starting from this, he discovered the law which has since borne his name.

Meyer's statement of his discovery appeared in 1891: Der accentuierte Satzschlusz in der byzantinischen Prosa vom 4. bis 16. Jahrhundert. The law is formulated in the following terms: Die Silben, welche einer Sinnespause unmittelbar vorangehen, sollen einen bestimmten Tonfall haben; hiebei soll aber nicht die Länge oder Kürze der Silben, sondern nur der Wortaccent berücksichtigt werden; und zwar sollen vor der letzten Hebung der Art mindestens 2 Senkungen stehen, wie *ἁπάντων ἀνθρώπων*; nach der letzten Hebung kann stehen was will; also: *διαλέγονται ἄνθρωποι. ἁπάντων ἀνθρώπων. ἅπας σοφός. σοφίαν τιμᾷ.*

It is noted that different writers seem to follow different principles in treatment of clausulæ before weak punctuation, some

observing the rule carefully at the stronger pauses only. In this connection it is remarked very justly that the condition of the text is a matter of great importance in the case of any writer whose clausulæ are studied.

In the reading of clausulæ such words as the article, conjunctions or adverbs (Hilfswörter der Sprache) are treated either as accented or unaccented according to the situation in which they stand. So the following cases are cited from Synesius as regular: *κατεξανίστη τοῦ πάθους. ἦν καὶ ἀνέφερον. προσπεσόντας οὐκ ἤνεγκεν. παθεῖν ὑπὸ Δίωνος. ἀδελφιδοῦν τὸν Ἰόλεων. ἀνάσχου τοῦ λόγου. φασὶ τὴν καρδίαν. ἐπιλαθέσθαι με οἷόν τε.* The cases cited would excite little scepticism, but there was need to define very carefully exactly what "Hilfswörter" can be so treated, because scholars could not readily agree on just what words in Greek do bear a weak spoken accent.

Meyer makes much of the secondary accent. There must be one present in such cases, he says, as *ἅπαντα φιλοτιμούμενος*, in the very nature of things, and the use of the secondary accent to mark the thesis in accentual poetry shows this factor to have been a real one in spoken Greek, just as it is in any language where accent is a matter of stress. This is reasonable enough, but Meyer introduces the secondary accent into his clausulæ in a quite arbitrary way. For example: *ἄρα ἐ***ποτνιώμην. περὶ τῆ***ς ξυμφορᾶς. τινι φι***λοτιμούμενος. θαυμασιώτερο***ς ἂν φανῆναι.* The uncommon occurrence of the form *ἐπαινέσαι προελόμενος* is explained as due to the presence of a secondary accent on the middle one of the three unaccented syllables, thus making the clausula equivalent to ⏑́ — ⏑́ — ⏑́ (— —). Whether this be the correct explanation or not, it is one of the weak points of Meyer's statement that he does not mark off this form of clausula from the rest as irregular. That these cases with three syllables in arsi[1] do occur is justified by a supposed "falscher Nebenaccent", which stands on the first of the three syllables instead of on the second, as it normally would, thus: *χλαμύδα*** *ἐνειμένος.* But this procedure can not deserve serious consideration.

As a result of admitting free play of the secondary accent in clausulæ Meyer goes to the extreme of counting perfectly normal only that form which has two syllables in arsi. He is too reckless in abandoning written accents and reading this form into all such

[1] *Arsis* is used here and in the following to denote all the syllables without ictus standing between two spoken accents, *thesis* to denote the two stressed syllables between which are included the syllables forming the arsis.

cases as the following: μυριάσιν ἐπιστρατεύσαντος. πεποίηκεν ὑποχείρια. He instances Sophronius as a writer who consistently showed this form by written accents without the aid of a secondary accent, but adds that such writing is very rarely found.

Meyer's article is carefully reviewed by Louis Havet, Revue Critique 32 (1891), p. 207. The weakness of Meyer's treatment of the form $\dot{-}\,-\,-\,-\,-\,\dot{-}\,(-\,-)$ is plainly brought out by Havet, who justly criticises Meyer's confusion of certainly correct with questionable clausulæ.

Other shorter notices by Jacob Wackernagel, Beiträge zur Lehre vom griechischen Akzent, Universitätsprogramm, Basel 1893, p. 7, and Gustav Meyer, Berliner philol. Wochenschrift, 1892, p. 182, express unqualified approbation of the accentual law. Wackernagel finds the use of the grave accent in clausulæ supporting his theory that this accent mark had come to indicate a stress simply without distinction from the acute or circumflex (p. 7). Indeed it would seem to be a general assumption that all kinds of accent are used indifferently and without distinction in the thesis of clausulæ [1]; yet detailed statistics are required to make the situation absolutely certain, since there is no *a priori* reason for believing that already in the fourth century A.D. a grave accent had ceased to be distinguished in value from an acute or circumflex, and that an acute and circumflex were merely different signs for the same stress accent, as they are in Modern Greek. Here the question may be stated in perfectly definite terms: do the writers who observe Meyer's law use the grave, acute and circumflex indifferently in their clausulæ?

A detailed test of the law is offered by Curtius Kirsten, Quaestiones Choricianae (Breslauer philol. Abhandlungen, Band 7, Heft 2, 1894), Pars Tertia, p. 36. The law of Meyer is adopted *in toto* by Kirsten, and the clausulæ all counted with a view to determining the exact extent of the cursus law's application in Choricius. Although only two percent of the total number are found irregular, Kirsten is unwilling to agree with Meyer's statement that Choricius follows the law throughout: "Faveri videtur 'legi' Meyerianae"; and he is unwilling to admit the test of the cursus law as a criterion in restoring Choricius' text. Kirsten further criticises Meyer's statement as to the treatment of "Hilfswörter" in clausulæ, and very fairly declines to extend the same license without reserve to all adverbs and pronouns. Meyer's doctrine of the secondary accent is strongly criticised.

[1] Cf. Litzica, Das Meyerische Satzschlussgesetz, p. 9, n. 2.

Kirsten set forth in detail the different varieties of hiatus found in Choricius (Pars Altera, p. 25), but he goes no further than the manuscript tradition except in rare cases, and leaves out of account the question whether such cases of hiatus as δὲ ἦν were not uniformly avoided by elision in speaking or reading. This is an important question in reading clausulæ, because the number of syllables in arsi is reduced by one if elision be admitted in such a case as ἰότε δὲ ἦν.

A test was made by K. Krumbacher, Ein Dithyrambus auf den Chronisten Theophanes (Sitzungsbericht der k. bayer. Akad. d. Wiss. 1896, p. 583), and Eine neue Vita des Theophanes Confessor (same publication 1897, p. 371), which is of especial interest from the palæographical standpoint. Two punctuated manuscripts came under his observation in the study of these works, and he counted the clausulæ before all the periods indicated in the two manuscripts with a result decidedly favorable to Meyer's law (p. 598 ff.); in one case (a Munich manuscript), from a total of 256 cases, 239 were found regular as understood by Meyer, as against 17 irregular; in the other case (a Moscow manuscript), a total of 330 cases contained 286 regular, as against 44 irregular. It is observed that the manuscripts of the accentual Church poetry of Byzantine times use the same signs in marking verse endings as those found in these two manuscripts. Yet too much stress should not be laid on these marks as indicating the cola of rhythmical prose because punctuation is found in manuscripts of prose writers who lived before the cursus law existed. The practice in the use of commas in these two manuscripts is noteworthy; Krumbacher finds them used both to mark genuine sense pauses between clauses, and also in cases where no pause can be intended, but where the mark of punctuation can be of assistance to the eye in reading; for example, a comma is found after ὁ μέν. In this latter case the comma can not be considered as marking a rhythmical clausula, though it does in the former.

In the year following Krumbacher's second article an attempt was made to define still more accurately Meyer's law by Konstantin Litzica, Das Meyerische Satzschlussgesetz in der Byzantinischen Prosa; mit einem Anhang über Prokop von Käsarea, München 1898. Litzica rightly maintains that some definite criterion must be furnished for the detection of the cursus and the classification of writers according as they observe the law closely, or carelessly, or not at all. The first test is derived from a mathematical computation of the possibilities of the language itself. For this purpose a typical writer was chosen—Leontius of Naples (7th cen-

tury)—and from his language a calculation was made of the total number of possible regular cases, and of possible irregular cases. This was done in the following way: a word accented on the first syllable such as *ἄνθρωπος*, if preceded by an oxytone or paroxytone, makes an irregular form, but a regular form is produced if it be preceded by a proparoxytone[1]; a word accented on the second syllable such as *σκοπός* combined with a preceding oxytone makes an irregular form, while any other possible accent on the preceding word makes a regular form; then words accented on the third syllable such as *γενεά*, or on the fourth or fifth or sixth or seventh, may be preceded by any accent at all without producing a form which violates Meyer's law. All words may now be classed according as they bear an accent on the first syllable, second syllable, and so on—seven classes. Then they may be again classed according to the position of the accent relative to the end of the word—three classes: (1) oxytone, (2) paroxytone, (3) proparoxytone. Then from the numbers of these two sets of classes may be computed the total number of possible regular forms, and the total number of possible irregular forms. Since monosyllables and "some dissyllables" do not seem admissible in the reckoning on the same basis as polysyllabic words, they are temporarily left out of account. The sum total of all possible clausulæ resulting from every possible arrangement of the 12,172 words counted was 148,157,564. Of these the total of possible regular forms was 95,083,089, and of irregular forms 53,074,475. Finally, in order to take account of the monosyllables, (where the written accent "gar nicht helfen kann"), all the clausulæ in the same Life of Leontius are counted, and the cases containing monosyllables (334 in all) divided into regular (308) and irregular (26) forms. Then these percentages (92.22 % regular and 7.78 % irregular) are added to the corresponding percentages of the possible forms in polysyllabic words:

$$64.17 + 92.22 = 156.39 \text{ regular.}$$
$$35.83 + 7.78 = 43.61 \text{ irregular.}$$

These results divided by two give the following result: 78.195 % regular; 21.805 % irregular. Litzica concludes thus: Die mittelgriechische Sprache ist so beschaffen, dass sie zwischen den sämtlichen Wortcombinationen das Verhältniss von ungefähr 80 dem Meyerischen Gesetz nach regelmässigen, gegen 20 unregelmässige darbietet. This, then, constitutes a test whereby a writer's language

[1] Litzica includes perispomena under oxytones, properispomena under paroxytones.

may be judged; if his clausulæ show no more than 80 regular cases out of every 100, he can not be said to observe any law, because there must be at least 80 regular from mere accident. This result would be a welcome help in the study of the cursus if it were convincing, but it can not be accepted as the correct one; in the first place, the monosyllables were reckoned with only in clausulæ, while the polysyllabic words throughout the sentence were included in the computation; in the second place, all cases with 3 or 5 syllables in arsi are counted on the regular side. This will be shown later to be absolutely wrong.

Litzica seeks a second means of detecting the presence of the accentual cursus by a comparison by statistics of the percentage of regular forms found in classic writers with that found in those writers in which the law seems to be operative. Tests in different writers are found to give the following result: Lysias 73 % regular; Demosthenes 69 % regular; Polybius 85 % regular; Dionysius of Halicarnassus 82 % regular; Josephus 84 % regular; Plutarch 85 % regular; Lucian 75 % regular; Aelius Aristides 80 % regular. All these writers show a clear majority of cases regular. Tests are also made of Greek later than the Byzantine period as follows: Koraïs, Autobiography 88 % regular; Georgios Mistriotes, President's speech, 1891, 87 % regular; in the leading article of the newspaper Acropolis, April 1, 1896, 86 % regular. These figures taken together show that the Greek language of every period contained many more clausulæ of Meyer's regular forms than of the irregular forms. This method of defining the cursus is surely the right one, but Litzica fails again in that he consistently counts regular all those cases in which 3 or 5 syllables stand in arsi. Then there follows an account of tests made in 44 different Greek writers from the fourth to the fifteenth century, with a table showing the relative standing of all the writers tested according to their tolerance of irregularity in the application of the law. Three classes of writers are now distinguished: (1) those who followed the law closely, allowing 5 % or less of irregularity—18 writers; (2) a middle class who allowed between 5 % and 10 % of irregularity—3 writers; (3) those who allow more than 10 % of irregularity are considered as knowing nothing of a cursus law—23 writers.

This classification shows about half the writers tested to be outside the influence of Meyer's law. This fact leads Litzica to protest against Meyer's position that there is any law existent. The law, he maintains, is not universal in that it does not control all the writers of the period, nor is it universal in any single

writer. What we have is merely an artistic device, a rhetorical trick which was used or disregarded at will.

A later publication which makes use of the law is by Paul Maas, Rhythmisches zu der Kunstprosa des Konstantinos Manasses (Byzantinische Zeitschrift 11, 1902, p. 305). The law is stated by Maas with a very significant modification of the form in which it was previously stated by Meyer and received by Litzica: between the last two accents only an even number of syllables may stand. This leaves the type with 3 and 5 syllables in arsi among the irregular clausulæ. The importance of this will appear presently. Maas remarks on the difficulty of punctuating in accordance with the cursus; the ordinary placing of commas in Greek texts seems in general correct, but there seems reason to doubt whether a comma should be permitted before a relative sentence, since a regular clausula is often not to be found in that position.[1]

Part II.—The Law Itself.

When Meyer formulated the cursus law, he wrote with his attention fixed on the rhythmical prose itself; he neglected to justify his statement of the law by a careful and detailed comparison with prose in which such a rhythm does not exist. The general characteristics of the accentual cursus struck him so forcibly that he failed to see more than two fundamental facts: the preponderance of a form having two syllables in arsi, and the constant avoidance of forms having no syllables or one syllable in arsi. Hence his statement of the law that two or more syllables must stand in arsi. The law thus stated includes too much, since forms which do not in any sense characterize the cursus are massed together with the really characteristic forms. Obviously the only satisfying method of finding out exactly what is characteristic of the accentual prose rhythm is a comparison by individual forms of clausulæ between writers who show a cursus and writers who do not. Meyer readily saw that the form having three syllables in

[1] The accentual cursus law is incidentally noted in Norden, Kunstprosa; Krumbacher, Geschichte der Byzantinischen Litteratur; Havet, Cours élémentaire de métrique grecque et latin. Important works on the Latin accentual cursus which treat incidentally of the law in Greek are: Havet, La prose métrique de Symmache, 1892; W. Meyer, Die rhythmische lateinische Prosa (Gött. gelehrte Anzeigen 1893), reprinted in Gesammelte Abhandlungen zur mittellateinischen Rhythmik 1905, vol. II.

arsi was only admitted on sufferance, but he left this matter in such a form that all who have since used the law in Greek prose, with the single exception of Maas, have adopted the law in a form which counts this form just as regular as the form with four syllables in arsi. The very fact that form 3[1] is less common than form 4 arouses suspicion, since form 3 may reasonably be expected to be more common than form 4 in clausulæ where no law regulates the position of word accents. Here it should be noted that the Latin accentual cursus uniformly avoids form 3[2]; the Latin law is the law stated by Maas: only an even number of syllables can stand in arsi.

It has been made practically certain that the Latin accentual cursus was a direct development of the earlier quantitative cursus used by such writers as Pliny.[3] It is interesting to note that for Symmachus and all other writers for centuries following Havet considers the quantitative cursus fundamental, and indeed denies that any accentual cursus as such existed before the twelfth century A.D., while Meyer holds that the accentual cursus was already plainly present towards the end of the fourth century, and gradually supplanted the quantitative cursus. If, then, this accentual cursus which seems to be common to Latin and Greek prose of the same period is a historical development from the Latin word accents in the quantitative cursus, this fact would seem to preclude the possibility of an independent origin for the Greek accentual cursus[4]; but the details of usage must be worked out in each language separately. The points of divergence as well as the points of contact must be defined.

Since the question of possible forms is made perfectly clear by a simple test, we need not delay longer over generalizations. The convincing test desired consists, as suggested above, in a detailed comparison by statistics of writing where the accentual cursus

---

[1] The clausulæ are classed and referred to as follows:

Form 0 (no syllables in arsi) *πρεσβευτὴν ἔβλεπον*
Form 1 (1 syllable „ „) *νικήσει δοῦλον*
Form 2 (2 syllables „ „) *προτείνεται λόγους* (regular)
Form 3 (3 „ „ „) *εἰς ἔδαφος καθεῖλεν*
Form 4 (4 „ „ „) *ὅτι τάχιστα ἀπαλλάσσεσθαι* (regular)
Form 5 (5 „ „ „) *πολέμια γεγυμνασμένων*
Form 6 (6 „ „ „) *ἐπελευσόμενοι τοῖς ὑποζυγίοις*

[2] Cf. Havet, Symmachus, § 19.

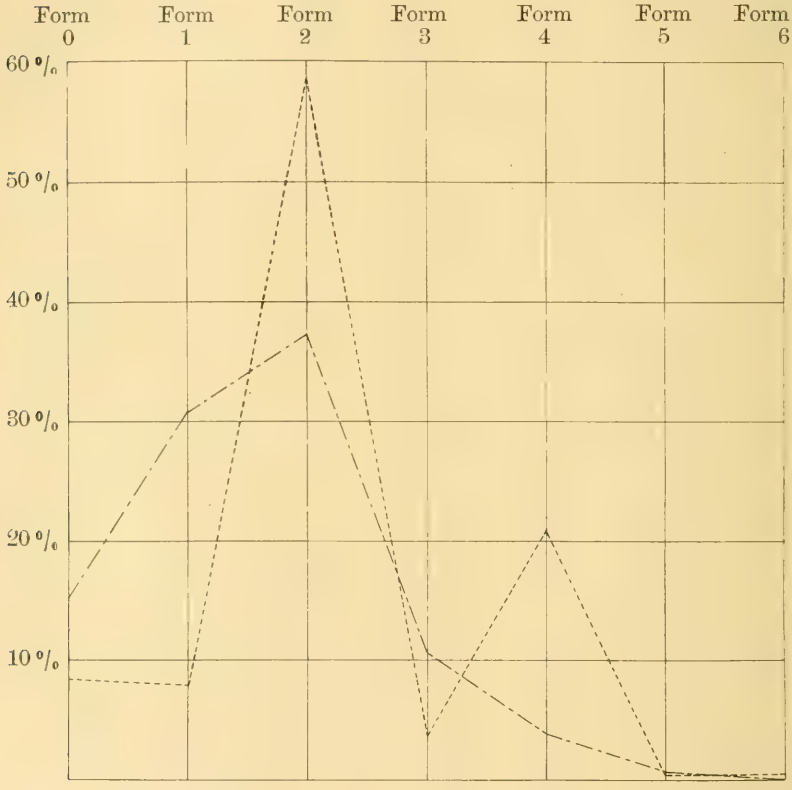
[3] Cf. Havet, Symmachus; and W. Meyer, Die rhythmische lateinische Prosa.

[4] Cf. against this view G. L. Hendrickson, Am. Journ. Phil. 29 (1908) p. 280.

rhythm is present with writing in which such a rhythm can not exist.[1] Such a test must be made with absolutely nothing taken for granted; every clausula must be counted and classified, not merely as regular or irregular, but according to its form: 0, 1, 2, 3, 4, 5, 6. Further, no deviation must be admitted from the traditional written accents of the grammarians. This will certainly introduce a slight error, but this error can be corrected with the help of what appears certain after a preliminary attempt has made general principles clear. Every scholar can satisfy himself, but no one else, as to just what monosyllables can stand in arsi. Whose understanding of the matter can be confidently adopted when all disagree? It is far more satisfying and convincing to stick to the grammatical accents in marking out the general lines which the cursus follows. Everything is thus made definite and open, and the influence of subjective feeling completely eliminated. If the written accents alone can be found to distinguish cursus writers from others, then a vast deal is gained, and we may start from a plain scientific fact to work out details of usage. In the following count, therefore, every written accent is counted of equal value, whether it stand on a conjunction, preposition, noun or any other word, and whether it be grave, acute or circumflex. The different kinds of accent must be separated ultimately, and the question of their relative importance answered. Since this is a question of detail, it may be disregarded for the present. Further, although the cursus law is observed before every sense pause, we can not be sure that our commas mark the pauses as understood by the Greeks themselves, and must begin by counting only the pauses before the stronger marks of punctuation—the period, colon and interrogation point. The writers chosen for comparison on this basis are the historian Zosimus (5th century) and Demosthenes, the passages being chosen at random, and the clausulæ counted consecutively. The figures are striking and can best be shown on a chart (p. 426). The forms of clausulæ found with greatest frequency in Zosimus are those designated as 2 and 4, while forms 1, 3, 5 and 6 are strikingly rare;

[1] In Greek we may feel on perfectly sure ground in comparing writers who wrote in an accentual cursus with those who have a quantitative cursus, if the theory of Havet and Meyer is true as to the origin of the Latin accentual cursus. The case is not as it would be in Latin where the comparison would be between earlier and later stages of a continuous development, for the word accents of the Greek quantitative clausulæ should contain no suggestion of the accents of the accentual cursus.

form 0 seems to be favored above 1, 3, 5 and 6, but this result will later appear to have been abnormal. On the other hand, the arrangement of written accents in the clausulæ of Demosthenes is plainly an accidental one; there is no design apparent in his usage; there *is* design in the usage of Zosimus. This test is in itself too

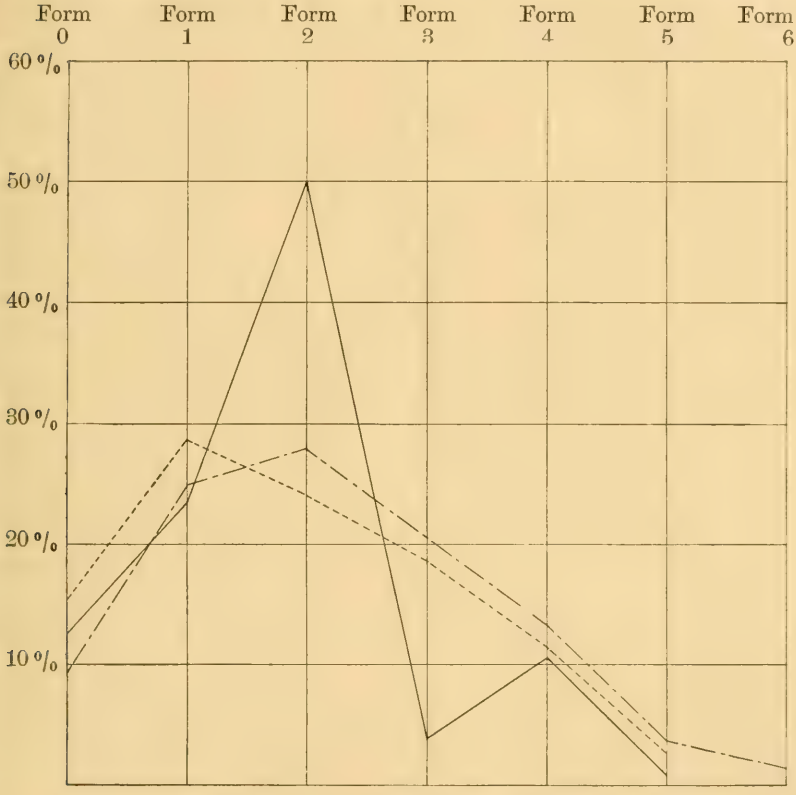


—·——·—— Demosthenes Androtion, ed. Blass.

---------- Zosimus III in Corpus Scr. Hist. Byz.

	Dem.	Zos.
Form 0	15.0+	8.0+
„ 1	30.9+	7.4+
„ 2	37.6+	58.5+
„ 3	11.0+	3.4+
„ 4	3.9+	21.4+
„ 5	1.3+	.57+
„ 6	0	.57+

limited in scope to form even a safe starting point. To make sure similar counts were made in Zonaras (12th century), and in Lysias and Pausanias. The test shows even more plainly than before the presence of a law in Zonaras of which Lysias and Pausanias knew nothing. There appear in the clausulæ of Zonaras



———— Zonaras I in Corpus Scr. Hist. Byz.

—·——·— Lysias Mantitheus, The Grain Dealers, Nicomachus, ed. Thalheim.

---------- Pausanias V, in., ed. Spiro.

	Zon.	Lys.	Paus.
Form 0	11.5 +	9.4 +	14.4 +
„ 1	23.5 +	24.3 +	28.8 +
„ 2	50.0 +	27.3 +	24.0 +
„ 3	3.5 +	20.9 +	18.2 +
„ 4	10.5 +	13.2 +	11.5 +
„ 5	.5 +	3.4 +	2,8 +
„ 6	0	1.2 +	0

75 + % of the preferred forms, while the remaining 24 + % fall into the avoided forms (five in all), while in Demosthenes, Lysias and Pausanias the percentage of these preferred forms (of Zosimus and Zonaras) falls considerably below 50 %.

These comparisons show a striking contrast between the two kinds of prose, and the characteristics of the accentual cursus are perfectly evident. It is not merely true that writers who use the cursus avoid forms 0 and 1, but also forms 3 and 5. As to what the law in general is there can be no doubt; the figures of themselves are convincing. Assuming nothing more than what is plainly demonstrated, the law may be stated in negative form thus: The cursus law requires that forms 0, 1, 3 and 5 be avoided. The original statement by Meyer must be revised; form 3 is as certainly avoided as form 1. Exactly the same forms are avoided as in the Latin cursus. This is no mere trivial correction, as may be readily seen by returning to Litzica's work.

In the first place, his mathematical computation of the possibilities of the language of Leontius gives an entirely different result when forms 3 and 5 are counted among irregular clausulæ as they must be. Counting thus the following result is obtained: out of a possible total of 148, 157, 564, only 61, 161, 874 regular combinations are possible—that is, less than half. The proposed test of 90 % regularity for writers who have a cursus falls absolutely to the ground. The total of regular cases which may be expected where no law is present is really 50 % or less, not 80 % as Litzica holds.

The other point in which Litzica arrived at a wrong result through his misunderstanding of the law is in the comparisons made between prose which conforms to Meyer's law and that which does not. He finds 69 % regular in Demosthenes, as against 95.35 % in Zosimus; this presupposes only forms 0 and 1 irregular. Now if the percentage of forms 3 and 5 are subtracted from this estimate, Demosthenes falls to 47 % regular, with a loss of 22 %, while Zosimus loses no more than 4.5 % and still stands above 90 % in regularity.[1] The mere fact that the loss by excluding these forms is so different in the two cases is of itself convincing. The same striking contrast can be pointed out between other writers: for example, of the 3 and 5 form together there are found 24.3 % in Lysias, as against 4 % in Zonaras. The contrast in the 3 and 5

[1] These figures show results when written accents are treated as Litzica does—counting out the article etc.—in order to have a safe basis of comparison with his results.

forms is scarcely less marked than in the 0 and 1 forms: Demosthenes has 25.2 % of 0 and 1 forms in the entire oration On the Crown (ed. Blass), while Zosimus III has 4.2 % of the same forms. If forms 0 and 1 are irregular, then forms 3 and 5 are certainly so. It is therefore evident that by including forms 3 and 5 as regular in such comparisons Litzica made all his conclusions useless. The law loses half its meaning by a comparison on this basis. It is rather one of the characteristic marks of the cursus rhythm that forms 3 and 5 are avoided.

It has been suggested by Paul Maas [1] that form 6, when it occurs, should be counted as regular as forms 2 or 4; in other words, that the law requires an *even* number of syllables between the last two accents. In the nature of things the 6 form is very rare (in Zosimus they scarcely exceed the 5 form in frequency), and it is difficult to find any basis for judgment without a very extensive collection of material. The 6 form does not exist in Latin, but there seem to be some cases in Greek; since they are so uncommon, they need not enter into a general discussion. Until they are certainly found to be regular it is safest to leave the law in a negative form, as given above.

Now that the actual law has been seen through the written accents, it is possible to work out the details of its application. Any satisfactory conclusion must be deduced from the facts themselves; but before proceeding to a statement of such facts, some general observations may be in order. First of all, to take Zosimus' History as typical of the rhythmical prose, the case may be stated as follows: granted that Zosimus favored two particular forms in the arrangement of accents in his clausulæ to such an extent as to make 75 % of all cases conform absolutely to these forms, while five other possible forms are represented in only 25 % of the total, it is reasonable to inquire whether the preferred forms may not be recognized in cases where the written accent does not of itself make the preferred forms clear. A definite tendency toward a certain rhythm is apparent; can not this rhythm be found in apparently irregular forms without doing violence to the language?

We are dealing with a stress accent in Greek of this period, at least similar to the stress accent in English. If now, Zosimus even unconsciously sought the rhythm of the 2 and 4 forms, his procedure would be analogous to that of a person writing English verse. Here not every word has an accent, nor does the verse accent in

[1] Rhythmisches zu der Kunstprosa des Const. Manass., Byz. Zschr. 1902.

every case coincide with a strong word accent, but a secondary accent of a polysyllabic word may occasionally mark the rhythm. To quote from Prof. T. D. Goodell: "To produce English verse in a desired rhythm, words are so selected and arranged that strongly stressed syllables come naturally into enough of the more prominent and regularly recurring times of the intended pattern to determine how the other syllables are to make the rest of the pattern."[1] This is exactly what Zosimus has done; the arrangement of word accents in his clausulæ makes clear a preference for two definite patterns, and the preponderance of these characteristic forms where they are clearly marked by written accents raises a strong presumption that the rhythm of these patterns must be uniformly present in all his clausulæ. The question thus raised resolves itself into this: what was the spoken accent of the word groups in question as they stand in their context? The cursus rhythm was undoubtedly intended for the ear, and not for the eye. Now though there is reason to believe that written accents do not in each case represent spoken accents in connected discourse, yet some definite evidence is needed to support the evidence of the cursus itself; to prove, for example, that the accented forms of the article were not as strongly stressed as the accented syllable of a noun or verb.

Fortunately the evidence desired is at hand in the so-called Political Verses, which have an accentual meter instead of a quantitative basis as in classical Greek poetry.[2] We can feel on sure ground in dealing with verses of a simple structure; the lines uniformly contain 15 syllables with the movement iambic. Here we may expect to find a safe basis for reading the accentual rhythm of the cursus. We see, first, that not every word bears a metrical accent; monosyllabic words often form the arsis of a foot, even though they bear a written accent; for example, the article in all its forms, *μέν*, *δέ*, *καί*, and the copula *ἦν*. The same is true of the monosyllabic enclitics and proclitics *τε*, *γε*, *τι*, *εἰς*, *ἐν*, *ἐξ*; all these are used in arsi—in other words, have no metrical accent; second, there is no consistency in the treatment of the accents of these monosyllables; for example, *μέν*, *δέ*, *καί* often do bear an ictus, and even enclitics or proclitics may be treated in this way; for example, *κράνος τε καὶ δόρυ*; so *γε* is found with an ictus; third, in dissyllabic

[1] Unpublished Lectures; Yale University.

[2] Political Verses were examined in the following writers: Michael Psellus, Migne 122; John Tzetzes, ed. Kiessling; Constantinus Manasses, Corpus Scr. Hist. Byz.

words the meter sometimes requires an ictus on the syllable without written accent, while the accented syllable stands in arsi; this license is generally limited to relatively unimportant words, such as prepositions; we find κατά scanned as an accentual trochee, ὅτι as an accentual iambus, a fact which plainly suggests that these words were pronounced with only a slight accent, or with an accent which varied according to the nearness of stronger accents on other words. The situation in the Political Verses may be stated in general terms thus: the accentual rhythm is plainly based first of all on the written word accents, and these accents alone are sufficient to mark clearly the pattern of the rhythm; there are enough written accents falling in the metrical theses to define exactly where all the verse accents must lie. Some written accents are allowed to stand in arsi, but not all accents indifferently; the accents so treated stand on words which must have had slight, if any, independent stress in spoken discourse, except in certain special cases. The metrical excellence of the verse consists in the regulation of the licenses which the writer assumes in order to fit his language to the metrical scheme.

Just so in the cursus, which has likewise an accentual basis, the best writers may be expected to show the highest art in the limitation set on the licenses which they permit, rather than in a mechanical conformity to a rigid pattern. The treatment in the cursus of the weakly accented words such as the article may be illustrated from Zonaras, who makes about 75 % of his clausulæ conform to the cursus forms by their written accents alone, and seems to allow about 10 % plainly to transgress the law. To begin with the article:

ἀναρρηθῇ ὁ Δαβίδ.
πασῶν τῶν φυλῶν.
ἀπέστειλε τῷ Δαβίδ.

These cases are exactly similar as regards the cursus; neither τῷ nor τῶν has an independent accent any more than ὁ in the first example. Different cases are:

κινδυνευούσης τῆς κιβωτοῦ,
δῆλοῖ τοῦτο τῷ βασιλεῖ.

Here if the accents of τῆς and τῷ are counted as before, we have in both cases a clausula of the 4 form; on the other hand, by reading them *with* stress we have a clausula of the 2 form. What is to be done? We are not bound to consistency in counting out the accented forms of the article; the usage of the Political Verses makes so much clear. But as to whether the cases in question should be read as conforming to form 2 or form 4 is for the present

unimportant. They may with reason be assigned to either one of these classes. A different situation appears in the following:

Χουσὶ περὶ τῆς ξυμβουλῆς.
κατεδίωξε τοὺς πολεμίους.

Here nothing will save the cursus except counting the accent of the article as the leading ictus of the rhythmical unit. It seems unreasonable not to admit that the article in these cases is intended to have a full spoken accent. On the other hand, it is not safe to go to the other extreme and conclude that the article may be read with or without an ictus according as the law requires. That license has one limitation at least, namely the distance of the article from other stressed syllables. For example, it is hard to believe that in *πασῶν τῶν φυλῶν* (above), *τῶν* should have a stress at all approaching that of *πασῶν* in intensity; it is much easier to believe that in *ἀπέστειλε τῷ Δαβίδ* (above), the *τῷ* might have an independent stress approximately as strong as that of *Δαβίδ*; then in the last case quoted, *κατεδίωξε τοὺς πολεμίους*, the tendency to stress *τούς* is almost irresistible. This is plainly a case where certainty is out of our reach; we are forced to make our judgment depend on subjective feeling, supported by the evidence of the cursus itself. A working principle until a better one can be formulated is this: the article when immediately preceded or followed by a strong word accent is not expected to stand in thesi; when separated by one syllable from a strong word accent on either side, it *may* stand in thesi; when separated by two syllables from a strong word accent on either side, it is expected to stand in thesi.

The same principle applies to other monosyllables. Examples are:

τέθνηκε δὲ καὶ οὗτος.
πολλοὺς μὲν ἀνεῖλεν.
τεκμήριον δέ.
ὀγδοήκοντα δὲ βεβασίλευκεν.
ἢ δέ μοι οὐ δίδωσιν.

The same doctrine seems to govern the use of the prepositions; here the dissyllabic forms are treated exactly like the monosyllables. To begin with the monosyllables:

παραδραμὼν εἰς ἀσέβειαν.
εἶπε πρὸς Ἀχαάβ.
πρωΐθεν εἰς μεσημβρίαν.
τὴν ἅλωνα ἐκ τοῦ Ὀρνᾶ.
ἀπείρχθη πρὸς τοῦ θεοῦ.
ἀπῄει πρὸς Κροῖσον.

Examples of dissyllabic prepositions are:

εἶπον γὰρ αὐτῷ οἱ περὶ αὐτόν,
πατάξαι αὐτὸν κατὰ κεφαλῆς.
στρατεύματος μετὰ τῶν σαλπίγγων,
ἄμφω ἐπὶ ξηρᾶς.
αὐτῶν διὰ τὴν ἀπιστίαν.
ληνῷ ἀντὶ ἅλωνος.
Σαμψὼν διὰ τοῦτο,

Other words occurring less frequently in clausulæ which seem to show the same inconsistency of treatment are the negatives *οὐ* and *μή*:

λιπεῖν οὐκ ἐπείθετο,
Βαβυλῶνα οὐκ ἐθεάσατο.
πῦρ δέ γε μὴ ἐπενέγκωμεν·

Similarly the conjunction *ὡς* and the comparative adverb *ἤ* and the conditional conjunction *εἰ*:

προφήτην ὡς ζήσεται.
ἢ λιμῷ ἢ μαχαίρᾳ·
Ἀβεσαλὼμ εἰ νικήσειεν.

Besides these words which are all subordinate in relation to the main framework of the sentence, there are other words whose treatment in the clausulæ of Zonaras plainly indicates that the written accent does not always represent a spoken accent. First the copula in its non-enclitic forms:

ὁ προφήτης Μαχαίας ἦν.
δίκαιος ἦν.

The conjunction *ἀλλά*:

οὐκ ἀναστήσῃ ἐκ τῆς νόσου ἀλλὰ τεθνήξῃ.

The relative pronoun:

αἰτῆσαι ὃ βούλοιντο·
λαβεῖν τι ἐξ ὧν ἐκόμιζεν·

The substantive article:

ἀποκτεῖναι τοὺς ἔνδον.
οἱ δ' οὐκ ἐπαύσαντο.

Adverbs, especially in a set form like *εὖ ποιεῖν*.[1]
The pronoun *οὗτος*:

προκαταλαβοῦσα κρατεῖ ταύτης.
ἀναχωρήσειν εἰ ταῦτα λάβοι.

[1] Cf. Litzica, p. 34.

So the personal pronoun of the third person, *αὐτοῦ*. Cases are abundant in which *αὐτοῦ* and the other cases and genders of this word plainly carry an independent stress; for example:

μαχεσαμένους αὐτῷ.

On the other hand, cases are far from rare in which *αὐτοῦ* can have no full stress if the cursus is saved:

τοῦ πατρὸς αὐτοῦ ξύμβουλος.

Others show ambiguity:

βασιλεῖ αὐτῶν ἀπεκτάνθησαν.
ἐπέρριψεν αὐτῷ τὴν μηλωτὴν αὐτοῦ.

In the last case neither *αὐτῷ* nor *αὐτοῦ* can be stressed if the cursus is saved.

We should be very sceptical as to allowing the accented forms of the first and second personal pronouns to be counted as without stress; yet we find such a case as the following in Zonaras:

Οὐκ ἐλάλησεν ἐν ἐμοὶ κύριος.

If the clausula is regular, *ἐν* must bear an ictus and *ἐμοὶ* be counted as the arsis, unless *κύριος* be read, without stress.

A great number of cases bring us face to face with the question of hiatus and elision. The usage of the classical writers would lead us to expect to find hiatus carefully avoided in the comparatively artificial and imitative writing of the Byzantines. What we actually find in Zonaras, (to use him as an example), is this: first a great number of cases of hiatus which are partly justifiable as being "weak" —that is, after a long vowel or diphthong; second, a great number of cases handed down by the manuscript tradition in which hiatus occurs in its most objectionable form, namely cases which can be avoided by elision or crasis. For example:

ὁ ἀνήρ.
τὸ ὄνομα.
ὠνόμαστο ἡ γυνή.
αὐτόν τε ἔκτεινε.

On the other hand, elision seems to be frequent in the manuscripts:

κοιμωμένῳ δ' αὐτῷ.
ἐπ' ἔτη (followed by *ἐπὶ ἔτη* three lines below!).

The manuscripts therefore, as expected, show no consistency and have no bearing on the question. In order to settle upon a principle the clausulæ of two writers who show care in observing the

cursus rhythm were inspected with a view to determining just how far the best writers go in avoiding hiatus in clausulæ. To these is added the evidence of the Political Verses, which are of considerable importance, although they date from the latter part of the Byzantine period.

In Zosimus, Book I, as printed in the Corpus Scr. Hist. Byz., there are only 37 cases of hiatus before all kinds of punctuation inside the clausulæ, that is, in general, between the last two words of a clause. Of these the following are cases of weak hiatus, but have bearing on the question whether crasis or aphæresis are admissible in clausulæ:

1. *ἄλλους τε καὶ Οὐαλεριανόν,*	19, 5.[1]
2. *προέχον καὶ ἀξιώματι,*	23, 8.
3. *ἀναρχά τε καὶ ἀβοήθητα,*	35, 6.
4. *λάρισσα καὶ Ἀρεθοῦσα·*	46, 6–7.
5. *ἀνδρῶν τε καὶ ἵππων,*	47, 14.
6. *ἄδεκτα καὶ ἀπόβλητα,*	51, 19–20.
7. *ἢ ἐκ τύχης ἢ ἐκ προνοίας,*	60, 22.

It is noticeable that six of the seven cases involve *καί*. In every case except 1 and 4 crasis or aphæresis (in 7) would destroy a plainly correct cursus rhythm, and even in 1 crasis would not produce a regular cursus type, and would at the same time destroy the possibility afforded by the text as it stands, namely giving to *Οὐ* the consonant sound which appears in the Latin form of the name "Valerianus". This small body of evidence, therefore, gives no suggestion that crasis or aphæresis where possible should of necessity be read in clausulæ; on the other hand, it plainly indicates that hiatus is tolerated, even when the hiatus could be removed by either crasis or aphæresis.

There are many more cases of hiatus after a short vowel, cases, namely, where elision might be expected.

I. In ten cases a perfectly good cursus is made hopelessly irregular by introducing elision or crasis in reading:

εἰς τυραννίδα ἐξενεχθείη,	11, 20.
δι' ὑποψίας εἶχεν ὁ Ἀντωνῖνος,	15, 16.
καθ' ὅσον οἷός τε ἦν, διεκώλυε.[2]	15, 18.
πόλεων ἦν οἰκεῖα ἐποίει,	18, 23.

[1] References to page and line in the Corpus.

[2] In this case it is not clear whether the clausula ends with *ἦν* or with *διεκώλυε*; in the former case elision of *τε* would make a regular form impossible.

πρὸς τὰ καθεστῶτα ἢ γοῦν,[1]	26, 3.
ἀνθισταμένου, πάντα ἐπινεμόμενοι.	30, 5.
ὀχυρώτατα ἀνεχώρουν,	30, 19.
καταφυγόντες τε ἐκ τοῦ πλοίου,	49, 5.
φιλότιμος δὲ ὢν φύσει,	49, 7.
ἐνδόντος ῥεῦσαι τὸ αἷμα,	42, 13.

II. In nine cases a perfectly good cursus is destroyed, while a regular form can still be read after elision by subordinating heavy written accents:

ἐπεὶ δὲ πᾶσι ταῦτα ἐδόκει,	19, 10.
Γερμανοῖς τάγματα οἴσοντα.	26, 6.
Γαλλιηνοῦ παῖδα ἐπολιόρκει,	36, 10.
κορύνας καὶ ῥόπαλα ἐπεφέροντο.	46, 18.
τίνα δὲ ταῦτα, ἐρῶ.[2]	50, 14.
τοῖς ἐπιτεταγμένοις τὸ δρᾶμα ἐδίδου.	56, 22–23.
ὅσοι περ οἷοί τε ἦσαν, ἐπεραιοῦντο.[2]	58, 20–21.
αἰτήσεως οὐ πάντα ἀπέδοσαν.	59, 3 (stressing *οὐ*).
συνόντων αὐτῷ τὰ ἀνήκεστα,	61, 11 (crasis).

III. In five cases elision leaves a cursus just as plainly regular as the one destroyed, with *ἦν* or *ὦν* counted as without ictus:

παραθαρσύνας ὡς οἷός τε ἦν,	27, 17.
φυλάττων ὡς οἷός τε ἦν,	29, 17–18.
πολεμῶν, ἐν ἀπόροις τε ὤν,	29, 20.
χώραν ὡς οἷός τε ἦν,	37, 7.
αὐτοί τε καὶ τὰ ὑποζύγια.	41, 11 (crasis).

IV. In two cases neither elision nor crasis can be introduced to avoid the hiatus:

ἔτρεψαν εὐθὺ εἰς φυγήν·[3]	46, 1.
ζωγρίᾳ ἑλών.	59, 5–6.

V. The following three cases are irregular as they stand without elision:

1. *πλήθει οἴκαδε ἀπῆεσαν,*	27, 7.
2. *καὶ εἰ μὲν δεκτὰ ἐφάνη,*	51, 18.
3. *βαρβαραθεῖσα εἰς ὀλίγον τι,*	52, 9–10.

Of these 1 and 3 can not be read as regular forms without elision. In 2 elision makes a 2 form possible (stressing *μέν*), but the clausula is bad.

There are two cases of elision in clausulæ as printed in the text:

ἀνεχώρησαν ἐπ' οἶκου.	30, 17 and 32, 16–17.

[1] The punctuation may be questioned; the clausula should perhaps end with *καθεστῶτα.*

[2] Cf. p. 435, n. 2.

[3] If *ἐς* be read, the hiatus may be removed by aphæresis: *εὐθὺ 'ς φυγήν.*

The demands of the cursus are here against elision, and the full form *ἐπί* should be read, making form 4.

One case of crasis occurs in the printed text:

ὑπέστρεψεν εἰς τοὐπίσω. 34, 14.

Here the resolution of *τοὐπίσω* into *τὸ ὀπίσω* would still leave a possible regular form (introduced by an ictus on *εἰς*); hence no inference can be made.

To sum up, there are two cases in which the requirements of the cursus plainly demand elision (1 and 3 of class V); there are eight cases in which the requirements of the cursus make elision impossible (class I); the remaining cases can form the basis for no certain generalization, although eight cases in class II may justly be made ground for a very strong presumption against elision. The evidence before us plainly indicates, first, that Zosimus rather carefully avoided hiatus in his clausulæ; second, that in avoiding hiatus by elision he followed no consistent principle, but elided or omitted elision according to the demands of the cursus. This principle should be adopted in editing his text. In general elision is not expected, just as in the Latin accentual clausulæ.

In Procopius of Gaza, Panegyric to the Emperor Anastasius (Migne, 87–3), all cases before punctuation were counted. Only seven cases of hiatus are found in the clausulæ of the text as printed. Of these two are cases of weak hiatus:

ἤδη καὶ ὕπουλον, 2808 A.
πτωχοί τινες καὶ ἀνέστιοι· 2808 B.

In the first case crasis is unlikely; in either it would violate the cursus rhythm.

The remaining cases follow:

1. *τὸ κτῆμα ἐλογίζου·* 2797 C.

As the phrase stands, neither form 2 nor form 4 can be read, unless one goes to the unreasonable extreme of placing an ictus on *τό* and subordinating the accent of *κτῆμα*; whereas the easy elision of "*α*" in *κτῆμα* gives a clear case of form 2.

2. *βοηθεῖν δὲ οὐκ εἶχον·* 2813 A.

The situation here is reversed; the cursus requires that *δέ* be not elided. The other cases are ambiguous or doubtful:

3. *ἡ δὲ ἡμετέρα πόλις,* 2796 A.

The case is irregular, and no good cursus type is possible with or without elision; but the punctuation may be questioned.

4. *καὶ ἡ μὲν εἶχετο, ἡ δὲ ἔμελλεν,* 2805 A.

Here *εἶχετο, ἡ δὲ ἔμελλεν* scans correctly: ⏑ – – /– /– /⏑ – – –; but *εἶχετ', ἡ δ' ἔμελλεν* is equally good: ⏑ – /– /– /⏑ – – –.

5. *στρατηγῶν τε ὄχλος,* 2808 B.

Here the text is corrupt.

The following three cases show elision as printed (in each case of a preposition):

6. *τὰ μέγιστα παρ' ἀνθρώποις,* 2801 A.
7. *ὡς εἰκός, ἐπ' αὐτῷ·* 2816 A.
8. *πάλιν τὰ καθ' ἡμᾶς.* 2817 C.

In all these the cursus requires that the elided forms be retained.

To sum up: Procopius of Gaza very carefully avoids hiatus. Only one clear case appears (2) in which a hiatus avoidable by elision must be retained to keep the cursus, against four cases (1, 6, 7, 8) where elision must certainly be admitted, once against the manuscripts (*τὸ κτῆμ' ἐλογίζου*). Procopius of Gaza is plainly more careful than Zosimus in admission of hiatus, but one clear case forbids the conclusion that elision must be introduced to avoid hiatus wherever possible. Both writers are certainly inconsistent in regard to elision in their clausulæ.

In the Political Verses the neglect of elision is a matter which varies with different writers. In Constantinus Manasses, vv. 2500–2700 in the Corpus, there occurs no case of hiatus, while there are occasional cases of elision and crasis. One case of hiatus was found in another passage (v. 2306 *δύο ἔτη*), but it is clear that this writer does not admit hiatus of any sort except in very rare cases, and he consistently elides when hiatus can be avoided in this way.

In John Tzetzes, Historiarum Variarum Chiliades, ed. Kiessling, I, 1–204, seventeen cases of hiatus occur; of these five are justified by their position in the cæsura of the verse. One is a quotation of a familiar phrase: *ὧτα ὄνου* 130.

Four are cases of weak hiatus:

καὶ ὄνομα 67.
Κρανααῦ ὑπάρχων 173.
καὶ Ἀθήνης, 173.
τούτου Ἀλυάττης, 155.

Seven cases of plain hiatus are found:

1. *ἔχειν ὠτία ὄνου*	113.
2. *Γαρβαῖός τε ὁ στρατηγός*	74.
3. *ἐς τὸ Ἡραῖον*	37.
4. *Κροῖσος ὁ Ἀλυάττεω*	1.
5. *ὁ Ἐρέχθευς*	175.
6. *ὁ Ἐριχθόνιος*	172.
7. *καὶ τὰ ἀνάκτορα*	161.

Two of these (1 and 2) could be remedied by a natural elision, the remainder by crasis, but the meter requires that they be read with hiatus. Tzetzes, then, is not consistent; elision is occasionally omitted *metri gratia*, though in general hiatus of any kind is rare.

The indications are plain that the writers of Byzantine times had partly lost the feeling of abhorrence for hiatus which was fundamental in the best writing of prose or verse with the Greeks of the classical period. The language written in the sixth century A.D. was no longer the living spoken language which it had been in the fifth century B.C. The use of an accentual cursus shows the presence of a new element; the pronunciation of rhetorical prose was guided by a stress accent, that namely of the spoken language, instead of the pitch accent of the earlier period. The feeling for quantity may have largely disappeared; just so it seems plain that the feeling against hiatus had become much weaker.[1]

It is remarkable that the situation with the Latin cursus is somewhat similar, in that the accentual clausulæ of Latin writers are consistently read without elision. This fact is the more striking because the same contrast between the accentual cursus and the earlier quantitative cursus is thus found to exist in both Latin and Greek. Another point of contact here appears between the Greek and Latin accentual cursus.[2]

We may illustrate what is proposed for the reading of clausulæ generally by a few cases from Zonaras.

I. Cases in which elision is not present in the printed text of the Corpus.

A. Irregular forms:

ἄφετε αὐτόν.	133, 18.
οἴκαδε ἀπῆει,	82, 18.
συνεπορεύετο αὐτῷ.	90, 21.
σώματα εὑρέθησαν.	196, 9.

[1] Cf. W. Schmid, Der Atticismus, III 291, 292.

[2] On elision in Cicero's clausulæ see Th. Zielinski, Das Klauselgesetz in Ciceros Reden, Leipzig 1904, pp. 28, 29. On elision in the late Latin cursus writers (beginning with the fourth century A.D.) see Havet, Symmachus, §§ 209, 215; Meyer, Gesam. Abh. II, pp. 258, 261.

B. Regular forms:

ὠργίζετο ὁ θεός.	85, 11.
μηνυθέντα ἀπήγγειλαν.	135, 4.
σὺ δὲ ἠγνόησας.	141, 9.
βασιλεύσει σε ἐν αὐταῖς.	150, 18.

II. Cases in which elision is present in the printed text of the Corpus.

A. Irregular forms:

πλείους ὑπ' ἀλλήλων,	88, 3.
ἥσθη ἐπ' αὐτῇ·	355, 2.

B. Regular forms:

Ἰσραὴλ ἀντ' αὐτοῦ.	190, 18.
ὥρμήκασιν ἐπ' αὐτήν,	99, 15.

Disregarding the manuscripts, the clausulæ under I, A and II, B should be read with elision; those under I, B and II, A without elision.

In order to justify still further such procedure in a writer where many cases occur in which elision must be considered in reading the clausulæ, 200 cases were counted in Zonaras, reading with elision every case in which a short vowel which could be elided stands in a clausula, with the following result: preferred forms 60.5 + %; avoided forms 39 + %.[1] The preferred forms now stand to the others in the ratio of 3 to 2 instead of 3 to 1 as before, when elision was not so introduced. Even so there are enough regular forms to suggest plainly the cursus rhythm in Zonaras; but it is plain that this procedure is wrong when a similar test is made in Demosthenes: 21 cases of elision in clausulæ are found in about 200 cases in the Androtion in., and the result of introducing the unelided forms makes altogether one less regular accentual clausula in the total; that is, in 10 cases the change to the unelided form makes a preferred form of accentual clausula, while in 11 cases the change destroys a preferred form.

Zonaras	with elision	75 %	reg.;	without elision	60.5 %	reg.[1]
Demosthenes	„	„	41.5 %	„ ;	„	„	41 % „

Zonaras loses 14.5 %, Demosthenes .5 %; this of itself makes it almost certain that Zonaras' clausulæ are not to be read with consistent use of elision, although it is recognized that those of Demosthenes should.

There are several other questions which occasionally arise in the treatment of clausulæ, which are here noted in passing. In regard

[1] Counting by written accents.

to the secondary accent we must admit almost complete uncertainty at the outset. We dare not at present suppose that a secondary accent can be located in as arbitrary a way as it is in the Political Verses, where such an accent must be counted in every word which shows more than one syllable either before or after the word accent, because of the very nature of iambic meter. But the presence of a secondary accent may reasonably be recognized as a real factor in reading the cursus. Of one thing we may be sure: that every secondary accent must stand in such a position as to be separated by at least one syllable from the written accent of the same word. Beyond this it is all guesswork; in most clausulæ there is not room enough for a secondary accent of any consequence, and it is safest to ignore it wholly.

Another troublesome question is that of the accent of enclitics, and the acquired accent on the word preceding. It seems reasonable to hold that enclitics which have lost their accent should certainly not be read with a stress upon them, and so it seems to be in a majority of cases; for example:

γυναικί τινι ἐντυχών. Zon. 159, 9.

But this case also appears in Zonaras:

πάντες σοί ἐσμεν. 164, 1.

There is a further difficulty in reading the accent acquired from an enclitic. It is reasonable to believe that the acquired accent is weaker than the original accent of the word which takes on the accent from the enclitic; so the following case would seem to belong to the 4 form:

ἐπορεύετό τε καὶ ἔπραττεν. Zon. 112, 23.

But there is still the possibility of a 2 form, if the last syllable of *ἐπορεύετο* be stressed. Another case found frequently in Procopius of Cæsarea may be cited here:

οἷός τε εἶναι.

It would seem within reason to read the clausula as a regular 2 form without any stress on the ultima of *οἷος*. At any rate, we should not hesitate to read form 2 in the following:

ταύτῃ πῃ εἶναι.

It would appear clearer what should be done in such a case as this:

τὸν ἄνδρα φησίν. Zon. 112, 23.

A puzzling case is the following:

ὑποκεῖσθαί οἱ ὀφείλοντα.

It is plain that the cursus rhythm is violated by two successive accents inside clausulæ. It is fair to ask whether clausulæ may be introduced by the second of two successive accents; the question arises in such cases as this:

Ἑβραϊστὶ κύριος λέγεται.

The case is different in the following:

τὰ ὅπλα κατέθεντο.

Here the accent of *τά* makes no conflict with that of *ὅπλα*, but in the former case the accent of *Ἑβραϊστί* is at least equal to that of *κύριος* in weight, if not heavier. Now supposing the former of two accents so placed should entirely outweigh the latter, have we still a right to consider the clausula introduced by the second weaker accent, because it is two or four syllables removed from the last accent of the clause? For example:

ἐκ χειρὸς τῶν ἀλλοφύλων.
μάχης συρραγείσης αὐτοῖς πρὸς τὸν Σισάραν.
περὶ αὐτὸν οἱ ἱερεῖς.

According to the suggestions made above (p. 432), *τῶν*, *πρός* and *οἱ* in these clausulæ are not expected to bear an ictus strong enough to stand as the thesis of the clausulæ, and they can not be counted perfectly regular. Yet it seems to be going too far to assert that they are absolutely irregular.

The vexed problem of punctuation is closely involved in that of reading the cursus. It is plain that the law should be considered as operative at every sense pause, as is shown by the practical conformity to the law before each mark of punctuation in our texts. But the placing of commas must certainly be revised in many cases. Here a further question arises regarding pauses before and after parenthetical statements and before quotations.[1]

In the best writing there seems some reason to look for a continuous cursus running through whole sentences. For example, the rhythm of the 2 form of clausula is continuous through the following clause:

καὶ ἄλλα δὲ βάρβαρα ἔθνη συνῄει μεθέξοντα τῆς ἐγχειρήσεως.
Zos. 180, 22–23.

/ ⏑́ _ / _ / ⏑́ _ _ / ⏑́ _ / _ ⏑́ _ / _ ⏑́ _ _ / ⏑́ / _ _ ⏑́ _ _

Before our information is complete, a study must be made of syllabic quantity in the clausulæ; there may be some fixed prin-

[1] Cf. Havet, Symmachus pp. 21 ff.

ciple followed in this matter, and a connection may be discovered between the old quantitative cursus and that of the later period which was based on accent, although this is scarcely possible if the accentual rhythm originated in Latin, as held by Havet and Meyer.

Further the relative frequency of the different kinds of accent in clausulæ must be defined, in order to know whether the accents were of different value, as in classical Greek, or without distinction, as in Modern Greek.

Part III.—Zosimus.

The prose of Zosimus is taken as a good example of writing in which an accentual cursus is found with considerable regularity. A limited portion is chosen and the clausulæ therein classified, in order to get enough evidence to furnish a cross-section of his practice in the use of the cursus rhythm. All clausulæ before the heavier marks of punctuation in Book III[1] are treated in the following.

First of all, the result of counting by written accents alone is as follows: from a total of 350 clausulæ there appear 205 cases of the 2 form, 75 of the 4 form, and 2 of the 6 form—a total of 282 cases of the preferred forms (supposing provisionally the two cases of the 6 form to be regular), or 80.5 % of the whole number of cases counted. In other words, the written accent fits perfectly the regular patterns of the cursus in four fifths of all the cases. In this 80.5 % are included cases in which proclitics and enclitics stand in arsi. The 16 cases show the following words so used:

The article: *οἱ* (twice); *ὁ* (twice); *ἡ* (once).
The negative: *οὐ* (four times).
The prepositions: *ἐν* (once); *εἰς* (twice).
The enclitics: *τε* (once); *τι* (twice); *που* (once).

There are also included in this 80.5 % 13 cases in which the pattern fits badly, in that the accent of a weak word carries an ictus in the rhythmical unit:

1. *παντάπασιν ἦν·*	132, 15.	Cf. 145, 6.
2. *αὐτῷ καὶ ὁ υἱός.*	133, 10.	Cf. 166, 8.
3. *διάδημα τῇ κεφαλῇ.*	136, 6.	Cf. 162, 4.
4. *τὴν Ῥωμαίων ἀρχὴν τοῦ προτειχίσματος.*		171, 10–11.
5. *Νισίβαρα καὶ Νισχανάβη.*		162, 22.
6. *ἄλευρα εἶναι ἐργαζομένη.*	156, 11.	Cf. 166, 15.

[1] Corpus Scr. Hyst. Byz.

7. *Περσῶν οὖσαν ἑλῶν.* 158, 15.
8. *παρ' αὐτοῖς ὄντων ἐκπέμψαντες.* 167, 16.
9. *τούτων τῶν τόπων τινός.* 169, 5.

These cases are not all of the same character; there is little violence, if any, in reading form 2 or 4 in 1, 3, 5, 6 and 9. In the remaining cases the situation is much harder; it would seem real violence to place an ictus on *καί* in 2, *τοῦ* in 4, *οὖσαν* in 7 and *ὄντων* in 8.

The regular forms are found in 35 more cases when the accents of such words as the article are counted out, as suggested for the examples from Zonaras.

1. Accented forms of the article in arsi; 26 cases:

ἐθελῆσαι τῆς μάχης. 126, 5.
ποιήσεσθαι τῆς ὁδοῦ. 161, 19.
ἡγησαμένων τῶν στρατηγῶν.[1] 160, 16.

2. Prepositions in arsi; 2 cases:

Ἀρινθαῖον σὺν τούτῳ. 143, 13.
ἑτέρου περὶ ἡμᾶς· 123, 8.

3. Relative pronoun in arsi; 1 case:

ἄξιον ὧν ἐτόλμησε. 136, 18.

4. Conjunctions in arsi: *δέ*, 1 case; *καί*, 5 cases:

τότε δὲ ἔρημον. 144, 9.
Λουκιανὸς καὶ Κωνστάντιος. 143, 7–8.

5. Comparative adverb in arsi; 1 case:

αἱρήσειν αὐλὴν ἢ τὸ φρούριον. 156, 21.

There are a few cases which bring up the question of elision (such as *τότε δὲ ἔρημον* quoted above); these are treated according to the principles already set down for such cases.

Two cases are read as regular by eliding:

διεστῶσ' ἑβδομήκοντα, 143, 20.
ἑτέρους δ' ἀνεκατέστησεν. 155, 18.

In 7 cases elision or crasis is not introduced:

ἐπιτήδεια ἔχειν. 129, 12–13.
αὐτῷ τὸ ἐσόμενον. 137, 8.
ταῦτα τὰ ἔπη. 137, 9.
τότε δὲ ἔρημον. 144, 9.

[1] Here *τῶν* may be read as stressed and a 2 form read, or subordinated and a 4 form read.

εἶναι ἐργαζομένη. 156, 11.
μετὰ τῶν ἄλλων αὐτῷ καὶ ὁ υἱός. 133, 10.
πέντε καὶ ἑβδομήκοντα. 161, 3.

Perhaps aphæresis should be introduced in 1 case:

δέχεσθαι ἐμέλλησε. 153, 2–3.

Crasis occurs once in the text as printed, and should be so read:

αὐτῷ τε κἀκείνοις. 126, 12.

There remain 30 cases which do not conform plainly to the regular forms. Yet there are some in which the cursus rhythm may be suggested in spite of the apparent violation of the law. By subordinating what would seem to have been strong written accents, regular clausulæ may be produced[1]:

1. *καὶ πάντας ὅσοι τὸ λῃστικὸν οἷοί τε ἐγίγνοντο διαφυγεῖν ἔκτεινε.* 133, 1–2. (Form 6?)
2. *τῇ λοιπῇ στρατιᾷ συνέμιξαν.* 146, 18–19. („ 4?)
3. *καὶ τῷ στρατῷ ῥᾷον καταστῆσαι.* 155, 13. („ 4?)
4. *πυρσῶν βολὰς ἔλεγον.* 159, 23. 160, 1. („ 2?)
5. *Σαλούστιον τῆς αὐλῆς ὕπαρχον.* 173, 11. („ 2?)
6. *εἰς τὴν τῶν ὅλων ἀρχὴν ἐλθεῖν.* 173, 14. („ 4?)

In the following there seems to be no possibility of recognizing even a trace of regularity, unless, indeed, such licenses be assumed as synizesis of *εω* (9 and 20), and reading iota as a consonant[2] (12, 21 and 22):

1. *πρόθηλον ἐκφυγεῖν ὄλεθρον.* 144, 21.
2. *πολλοὺς δὲ καὶ ἐθελοντὰς ἐδέξατο.* 125, 6.
3. *μέρος οὐ μικρὸν τῆς ἐλπίδος ἐν αὐτοῖς ἐσάλευεν.* 125, 21.
4. *κατὰ Ῥωμαίων χεῖρας ἆραι.* 133, 14–15.
5. *καὶ τὰς τῶν ἱππέων ἴλας·* 142, 15–16.
6. *καὶ τὴν ὑστεραίαν ἡσυχίαν ἦγον.* 146, 3–4.
7. *ἀνάλογον τῷ σώματι.* 131, 15.

[1] With these cases may be compared clausulæ instanced as possible regular types by W. Grönert, Zur griechischen Satzrhythmik, Rhein. Mus. 54 (1899), pp. 593 ff.

πρὸς αὐτοὺς πάθει χρώμενοι.
τὸν αὐτοῦ κύκλον στρέφονται.
ὑψηλὴν ζώνην φέρονται.
ἐπ' αὐτῆς πάντα πράγματα.
ἀνατολῶν ἤδη λέγομεν.

[2] This license is frequent in the Latin cursus.

8. ἦει εἰς τὰς Ἄλπεις.[1] 138, 4.
9. μετὰ δυνάμεως ἀρκούσης. 147, 13–14.
10. κατεσκεύασε τοιόνδε. 149, 17.
11. καὶ λακκινάριοι καὶ βίκτωρες. 156, 1.
12. ἀναιρῶν πολιορκίας. 156, 6–7.
13. ἔπειτα δὲ πλείους. 156, 15.
14. οἱ Πέρσαι πλεονεκτεῖν ἔδοξαν· 165, 14.
15. τῷ στρατῷ παρέδωκεν. 162, 10–11.
16. ὃν καλοῦσι Ῥωμαῖοι μάγιστρον·[2] 165, 6.
17. τῶν πλοίων ἐπιβαίνειν. 159, 19–20.
18. κατέστησαν εἰς χεῖρας. 165, 4.
19. διὰ πάσης θεωρουμένου τῆς ἡμέρας. 140, 15.
20. σιτήσεως ἧς εἶχον. 150, 15.
21. Σελευκίας ὀνομαζομένης. 158, 8–9.
22. πολέμια γεγυμνασμένων. 125, 20.
23. ἀπὸ δερμάτων δὲ πεντακοσίων. 142, 23, 143, 1.
24. τῷ Ἰουλιανοῦ σώματι. 172, 8.

Among these 30 cases the irregular forms occur as follows:

Form 0 6 cases.
„ 1 9 „ .
„ 3 12 „ .
„ 5 3 „ .

It is noticeable that almost one half of the irregular cases are of the 3 form. There seems reason to suppose, therefore, that this form of clausula was the least objectionable form, at least less objectionable than forms 0 and 1. This seems the more reasonable because in prose where no accentual cursus is present both form 0 and form 1 occur more frequently than form 3.

The situation in Zosimus may be summarized thus: 80 + % are absolutely regular, reading by the last two written accents; 10 + % are regular by counting out the accents of weak words; 9 + % remain which seem distinctly to violate the cursus rhythm.[3]

[1] ἦει 'ς τὰς Ἄλπεις would be a regular 2 form, (considering the form of the preposition ἐς, with aphæresis).

[2] μάγιστρον, if pronounced according to the Latin accent of "magistrum" makes a regular form 2, but there seems to be no justification in assuming such a license; in the following case the use of the Latin accent would destroy a regular form:

οὓς σκουτὰρίους προσαγορεύουσιν 165, 10–11.

[3] This method of counting regular cases first as marked by written accents, brings into the regular forms cases which do not really show strict conformity to the form which the last two written accents alone

The final results thus obtained are here set down beside similar results from other writers, arranged according to the regularity of their cursus. It will be readily seen that these figures are quite different from those given by Litzica, though in most cases the passage chosen for a test was the same as the ground covered by him. In the case of Æneas of Gaza, it now appears that there is twice as much irregularity present as the 16 % which Litzica found, and little, if any regard is paid to the law. In Sophronius the range of regularity is apparently limited to the 2 form—a phenomenon which may be paralleled in only a few other writers.

Forms	0	1	2	3	4	5	6	Reg.	Irreg.
Zosimus[1]	1.7+	2.5+	65.7+	3.7+	24.2+	.8+	1.1+	90.0+	9.8+
Sophronius[2]	0	1	94	2	3	0	0	97	3
Andreas of Crete[3]	0	4	79	2	15	0	0	94	6
Agathias[4]	0	1	63	6	25	5	0	88	12
Basilius of Seleucia[5]	1.7+	0	74.7+	9.5+	13.0+	.8+	0	87.7+	12.0+
Synesius[6]	5	10	58	5	22	0	0	80	20
Æneas of Gaza[7]	3	10	49	21	15	2	0	64	36

It is not clear what should be done with the residuum of rebellious clausulæ in such a writer as Zosimus or Agathias. Here we are brought face to face with a question which is raised by Meyer's discussion. Meyer does not consider the law an inner law of the language itself, which would absolutely control the clausulæ of any writer

suggest. For example, such a case as *αὐτῷ καὶ ὁ υἱός* is a 2 form according to written accents alone, but not by any means certainly to be read so, on account of the heavy accent immediately preceding *καί*. If such cases are separated, the possible error is avoided. Zosimus shows only four such cases (see pp. 443–4) in 280 clausulæ; that is, by reading the clausulæ by the last two written accents, we are led astray in only 1.4+ % of the total.

[1] Book III in the Corpus.

[2] Orat. VII, Migne 87, 3, first 100 clausulæ.

[3] Orat. I, Migne 97, first 100 clausulæ.

[4] Book I in the Corpus, first 100 clausulæ.

[5] Orat. II, Migne 85.

[6] De Regno, Migne 66, first 100 clausulæ.

[7] Theophrastus, Migne 85, first 100 clausulæ.

Remark. Clausulæ are counted only before the heavier marks of punctuation.

who comes within its influence, but rather a fashion (Mode) which some writers consciously ignored. Litzica, as noted above, protests against the use of the word law at all; but there is still need to repeat all the tests made by him with the correct form of the law as stated above, and it is doubtful whether a single writer whom he classed as knowing nothing of the cursus will be found to be entirely outside the influence of Meyer's law. From Part IV it will appear that Procopius of Cæsarea, whom he considered far outside the law's influence, is really under the influence of the "fashion". The law is certainly much more far reaching in its application among the Byzantine writers than Litzica found it. This fact makes it evident that we are dealing with a law which some writers obeyed strictly, while the great majority of writers only showed a more or less decided tendency to conform to it. In some writers absolute regularity may fairly be expected, just as is the case with certain Latin writers such as Ammianus Marcellinus; each writer must be considered separately in order to determine where this condition exists. When the traditional text of a writer shows as much as ten percent of irregularity, we may well hesitate to insist that every clausula should be forced into regularity by doing violence to written accents or emendation of the text, but some principle should be found for editing such a text. Since the manuscript tradition is of the greatest importance in settling this question, this must always be carefully considered and used in the light of the cursus law. The final result for any writer who has a cursus can not be given until the complete evidence of the manuscripts is brought to bear. For the present it is only safe to say that it is not known whether such writers as Zosimus and Agathias intended to show absolutely regular conformity to the law or not.

Part IV.—Procopius of Cæsarea.

It is well understood that different writers of the classical period of Greek literature differed in their use of the quantitative rhythm. In some it is found very plainly marked, while in others it is used with much less care, while others again can be said to have no regular quantitative rhythm at all. The same situation may reasonably be expected in the Byzantine writers: there are plainly certain writers who have an accentual cursus, but seem to admit much more license in following the law than the best writers. In each

writer who belongs to this class it is a matter of importance to define as closely as possible the extent of the law's application.

Procopius of Cæsarea is one of the writers whom Litzica considered entirely outside the circle of those who made use of the accentual cursus rhythm—one of those who know nothing of the cursus.[1] It must always be borne in mind that Litzica's understanding of the law of the cursus was based wholly on Meyer's first statement. Proceeding on the hypothesis that forms 2, 3, 4, 5 and 6 are all regular, Litzica pointed out that the clausulæ of Procopius show scarcely any more regularity than those of a writer of the classical period. The statistics seem amply to justify his statement, but his hypothesis is wrong; all his figures represent only totals of regular and irregular cases, without distinction of the particular forms. It is clear from the above that of the five forms which he massed together as regular only two (or three) are in fact regular. It is therefore necessary to make a new test of Procopius with the understanding that only forms 2 and 4 (and possibly form 6) are regular.

The Persian War, ed. Haury, 1905, was used for the test which is described in the following. It should here be noted that this edition does not give us a text which is beyond question,[2] although it is based on a careful study of the Procopius manuscripts, nor is the apparatus criticus full enough to furnish all the evidence needed. All conclusions must therefore be made with reserve, and must constantly be regarded as conditioned by the judgment of an editor who takes no thought for the cursus law.

In order to be on safe ground, only the clausulæ before periods are taken into account. It is reasonable to overlook the clausulæ before the weaker marks of punctuation until complete certainty is reached with regard to the writer's usage in clausulæ where it is absolutely certain that the cursus rhythm must be present, if it is present at all.

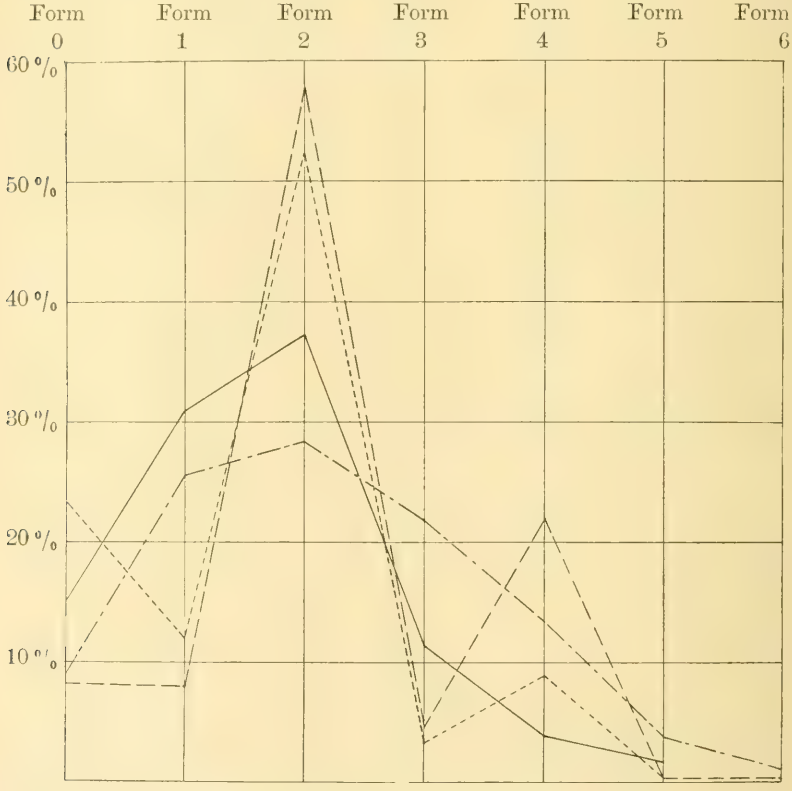
There are 4098 clausulæ before periods in the four books of the Persian War; these are classed according to the various forms, without any deviation from the written accents; the last two written accents are provisionally treated as the theses of the clausulæ, without regard to the kind of accent, or the apparent insignificance of the word on which the accent stands. The forms are distributed as follows:

[1] Compare the judgment of W. Crönert on Procopius: "—bei Zulassung jeglicher Hiate eine wohlberechnete Akzentrhythmik herrscht." Zur griechischen Satzrhythmik, Rhein. Mus. 54 (1899), p. 593 ff.

[2] Cf. W. Crönert, Gött. gel. Anz. 1906, p. 396.

Form 0– 920.
„ 1– 475.
„ 2–2197.
„ 3– 94.
„ 4– 387.
„ 5– 25.

The significance of these figures may be made clear by a comparison with classical writers on the one hand, and with acknowledged cursus writers on the other. The following chart shows plainly where Procopius stands.



— · — · — Lysias, Mantitheus, The Grain Dealers, Nicomachus, ed. Thalheim.
——— Demosthenes, Androtion, ed. Blass.
---------- Procopius of Cæsarea, Persian War, ed. Haury.
— — — — Zosimus III in Corpus Scr. Hist. Byz.

The percentages charted on the preceding page are here tabulated:

Forms	0	1	2	3	4	5	6	Reg.	Irreg.
Lysias	9.4+	24.3+	27.7+	20.9+	13.2+	3.4+	1.2+	42.1+	57.8+
Demosthenes	15.0+	30.9+	37.6+	11.0+	3.9+	1.3+	0	41.5+	58.2+
Procopius	22.4+	11.5+	53.6+	2.2+	9.4+	.6+	0	63.0+	36.7+
Zosimus	8.0+	7.4+	58.5+	3.4+	21.4+	.5+	.5+	80.4+	19.3+

It is to be noted that the proportion as between forms 0 and 1 in Procopius forms a striking contrast to that in all the other writers; but it is in the percentages of forms 2 and 4 that the characteristics of the cursus become apparent. In form 2 he stands much nearer to Zosimus than to the others; again in form 3 his usage shows real improvement on the cursus model; his preference of form 4 above form 3 is a regular characteristic of those writers who sought the rhythm of the accentual cursus. It is therefore plain that the cursus is present in Procopius, but the indications are that it is far from perfect.

There is still one factor to be considered; elision was not introduced in the reading of clausulæ except where indicated in the printed text. A large number of Procopius' clausulæ are concerned in this matter since there are many opportunities to elide short vowels between the last two words, as well as many cases in which aphæresis or crasis might reasonably be introduced. In the quantitative rhythm of Demosthenes all such cases of hiatus would be avoided in one of these three ways; further, there is every reason to believe that in the pronunciation of the living language of classical times elision was common. In order not to assume anything regarding Procopius, it must be considered conceivable that all his clausulæ be treated exactly as those of Demosthenes should in this particular matter. It is necessary to be absolutely certain that this factor will not make the above conclusions useless; the following table is therefore given to show the result when elision of a short vowel, wherever possible, as well as aphæresis and crasis are consistently introduced. Demosthenes, Androtion (ed. Blass) is chosen for comparison, and the figures given above are used again since they are taken from a text in which the editor consistently introduces elision, aphæresis and crasis in the printing.

Forms	0	1	2	3	4	5	6	Reg.	Irreg.
Procopius	23.7+	18.5+	45.8+	3.1+	8.2+	.3+	0	54.0+	45.6+
Demosthenes	15.0+	30.9+	37.6+	11.0+	3.9+	1.3+	0	41.5+	58.2+

This procedure leaves Procopius with a much lessened percentage of regularity—54 + as against 63 + in the former test—but the cursus characteristics are still apparent in the proportions of the 2, 3 and 4 forms. Leaving the question of elision, aphæresis and crasis for the sake of argument undecided, there is sufficient ground for maintaining that the cursus law is operative in the prose of Procopius. It remains to define the extent of its application; the principles followed are those deduced above from the usage of Zonaras and Zosimus.

In the following an attempt is made to enumerate all the cases in which the regular forms are to be recognized. It is safest to make a start from the formal classification by written accents alone.

I. Perfect clausulæ of the 2 and 4 forms.

In these cases the rhythm is plainly marked by written word accents, the written accents, namely, of the last two words, except in case an enclitic or proclitic intervenes; hiatus, if present, is weak.

Form 2. 1731 (2 I; 2 II)[1]

ἐφέρετο τῇδε.	72, 8.
τὸ παράπαν ἀνδρός.	225, 26.
γράφειν οὐκ ἔχω.	447, 10.

Form 4. 310 (4 I; 4 II)

μελέτας πεποιημένον.	131, 6.
δορυφόροις ὁ Μαξιμῖνος.	506, 23–24.

In 59 cases the thesis is marked by what would seem to be a weak spoken accent.

Form 2. 59 (2 III)

προβάλλεσθαι ἐν ταῖς ξυμβολαῖς.	267, 6.
εἶναι τοὺς πολεμίους. 387, 23; 388, 1.	(Form 4?)
οἷοί τε ἀντιτείνειν εἰσί.	176, 10.

In certain cases the force of the first accent is weakened by a heavy accent immediately preceding it.

Form 2. 65 (2 IV)

οὐδὲ φορητοὶ ἔδοξεν εἶναι.	455, 23.
ἡδονῆς γέγονεν αἴσθησις.	190, 15.
κυκλοτεροῦς οὔσης ὠνόμασται.	131, 15–16.

Form 4. 18 (4 III)

Γερμανῷ ἅπαντες προσεχώρησαν.	505, 13.

[1] The number of cases included under each head is given; the numbers in parentheses refer to the tables of forms (see Appendix).

The total of all cases included in Class I is 2183, more than half the grand total of 4098. These clausulæ are all regular in the strictest sense; in no case is a written accent disregarded.

II. Clausulæ to be read as of the regular forms, by departing from written accents.

A. There are, first of all, a large number of cases where a logically subordinate word, although bearing a written accent, may be read without stress, whereupon a regular form becomes evident. All these cases are certainly regular. The words whose accent is considered negligible are the following: the article in all cases, *καί* and *δέ*, *ἤ*, *ἄν*, *ἧ* (as) and the copula; the accents acquired from enclitics are treated in the same way as the accents which stand on these words.

Form 2. 149 (0, V, a, 1. 0, V, b, 1. 1, IV, a, 1, 3. 1, IV, b, 1)[1]

ἡσσημένους τὸ σύγγνωμον.	441, 20.
ὑπερείαις καὶ φάραγξι.	156, 6–7.
αὐτίκα δὴ μάλα.	255, 6.
πρέπειν ἂν δόξειε.	166, 17.
μᾶλλον ἤ πρότερον.	448, 3–4.
Περσῶν τῶν λογίμων.	113, 9.
θεραπεῦσαι ᾗ βούλοιτο.	25, 26.
τριχῶν πολὺν ὄντα.	64, 20–21.
(Counting *ὄντα* without stress.)	
ἔσεσθαι τοῦτό γε.	285, 5.
δέομαι δός μοι.	202, 22–23.
οὐδενὸς ἐνδεὴς εἴη.	450, 7–8.
(Counting *εἴη* without stress.)	
ἔδοξαν τῇ ξυμβολῇ εἶναι.	188, 19.
(Counting *εἶναι* without stress)	
ὧδέ πῃ εἶχεν.	479, 19.
τοιοῦτός τις ἦν.	126, 9–10.
μέγα τι χρῆμα.	519, 19.
ταύτῃ πῃ εἶχε.	300, 18.

Form 4. 35 (0, V, a, 2. 0, V, b, 2. 1, IV, a, 2. 1, IV, b, 2)

ξυνήνεγκεν ἐς τὰ μάλιστα.		369, 20.
οὐχ ἥκιστά γε τὸν Ἱρίαπον.	106, 14.	(Form 2?)
διεσώσατο τὰ ξυγκείμενα.		209, 12.
Ῥοδόπολος καὶ Μοχήρησις.		292, 17.
τέσσαρες στρατηγοὶ ἦσαν.		36, 25.
(*ἦσαν* without stress.)		

[1] The references to the tables under Class II refer only to the first two columns; see Appendix.

ἐπὶ τοὺς πολεμίους ἡ ξυμβολὴ ἔσται. (*ἔσται* without stress)	120, 24.
ἄντικρυς φανερὸν εἶναι. (*εἶναι* without stress.)	402, 19.

B. There are other cases where the pattern of the 2 and 4 form is present, but weakened by the presence of a heavy accent between the two accents which are taken as the theses of the clausula. Such cases should not be counted as strictly regular, and there should not be a great number of them in a writer who carefully sought the rhythm of the cursus. The presence of the rhythm should be clear without counting in cases of this type; they are regular only by sufferance.

Form 2. 150 (0, VI, 1. 1, V, 1)[1]

ἐν βεβαίῳ τὸ λοιπὸν θέσθαι.	198, 3–4.
εὑρόντες ὀλίγους τινὰς εὐθὺς ἔκτειναν.	143, 12–13.
ὕστερον δὲ καὶ πολὺ μείζων.	162, 18–19.
δυνατώτατος ὢν ἡμεῖς ἴσμεν.	125, 18.
ὑπὸ χερσὶ κυνῶν γένηται.	339, 20.
μεγαλοψυχίας εὖ ἦκων.	346, 21.
ἀμηχανίᾳ δὲ πολλῇ εἶχετο.	245, 22.
διαφυγεῖν μόλις ἴσχυσεν.	505, 9–10.
οὐδὲν τοῦτο πρᾶγμα.	130, 11.
ἤχθετο αὐτῷ πάντων μάλιστα.	134, 16.
ταῦτα μὲν δὴ οὕτως ἔσχε.	200, 2.

Form 4. 290 (0, VI, 2. 1, V, 2)

ἠνδραπόδισαν σχεδὸν ἅπαντας.	164, 5.
ἀμφὶ Κεῖλον ποταμὸν ἔχουσι.	104, 21.
αἱρήσειν οὐ πολλῷ ὕστερον.	295, 19–20.
οὔτι ἑκούσιον αὖθις ἤνεγκεν.	438, 1–2.
αἱρήσειν ἐν σπουδῇ ἔχοντες.	61, 5–6.
τοῦ περιβόλου ἐντὸς γενέσθω.	67, 16–17.
ἀπ' ἐναντίας αὐτῶν ἰοῦσιν.	81, 20.
τοσαῦτα μὲν καὶ ὁ Στότζας εἶπεν.	494, 8–9.
τὴν ἐπὶ θανάτῳ οἱ δῆμοι ἄγοιεν.	128, 3–4.
ἀδελφός, τέταρτος αὐτός.	501, 19–20.

III. Cases into which enters the question of elision, aphæresis and crasis.

A. Elision. There are altogether 421 clausulæ in the Persian War as printed in the text used in which a short vowel could be elided. As these cases stand without elision, 191 fall into the 2 form, and 38 into the 4 form. These cases correspond to Class I

[1] Many of these could be read equally well as 4 forms.

above; they are perfectly regular if the hiatus be allowed to stand. Here, then, are 229 cases which will not show conformity to the regular forms if elision be consistently introduced. The number of syllables in arsi being lessened by one, 2 forms become 1 forms, and 4 forms become 3 forms. In the same way 3 forms fall to 2 forms, and 5 forms to 4 forms; since the 3 forms as printed, where elision is possible, number 13, and the 5 forms 7, we should have only 20 regular cases left from the 421 before us. This strange result makes it seem unlikely that elision is to be consistently admitted; taking this body of cases alone, and avoiding elision, we find the six forms of clausulæ standing in about the same proportions as those found above to be normal for the Persian War; whereas consistent elision makes the proportions of the various possible forms absolutely different from the normal. The percentage of regularity is divided by ten; not only this, but form 1 would occupy almost half the field (191 out of 421). But since this body of 421 clausulæ is not taken at random from the whole, it is not safe to insist that the different forms can be expected to stand in the proportions found normal for the whole Persian War. But full and satisfactory evidence is at hand in the usage of other writers who show an accentual cursus rhythm and in the Political Verses, as set forth above. This evidence makes it clear that the following principle should be adopted for Procopius: elision need not he consistently introduced in reading clausulae, nor yet consistently avoided; the manuscripts are not a safe guide in such a matter, and elision may be introduced when the cursus rhythm requires it, and elided vowels may be restored against the authority of the manuscript tradition. On the other hand, the frequent hiatus which is produced by this procedure makes it plain that Procopius is not a careful writer according to the best standards of his time.

There are, as stated above, 229 cases which may be read as regular clausulæ by permitting the objectionable hiatus, without departing from the written accents.

Form 2. 191 (2, V)

ἐγένετο ὥδε.	122, 7-8.
ἄριστα εἶναι.	88, 24.
τόξα ἐνήργουν.	272, 17.

Form 4. 38 (4, IV)

παραγγελλόμενα ἐκτελεῖν.	514, 7.
ἐν τῷ παρόντι ἀνδραγαθίζεσθαι.	468, 13.
ξύμπασα ὠνομάζετο.	461, 5.

Form 3. 13 (3, IV). becoming 2 forms by elision.

ἐς τόδε ἐτελεύτα. 45, 12–13.
τὰ γράμματα ἐποίει. 363, 16.

Form 5. 7 (5, III). becoming 4 forms by elision.

ἀξιοθέατα ἐπιεικῶς ἐστι. 199, 2–3.
ἐναντίωμα ὑποτοπάζων. 113, 11.

The following cases containing hiatus are certainly to be added to the regular list; here the accent of a weak word is counted out as in Class II, A above.

Form 2. 22 (O, V, a, 1. O, V, b, 1. 1, IV, a, 1. 1, IV, b, 1)

οἷοί τε εἶναι. 281, 3–4.
ξυγγραφῇ δὲ ἀλήθειαν. 5, 13.
ὑμῖν δὲ ἡ μάχη. 421, 21–22.

Form 4. 5 (O, V, a, 2. O, V, b, 2. 1, IV, a, 2. 1, IV, b, 2)

ἤνυτον δὲ οὐδέν. 409, 7–8.
ξυνέκειτο ἐς τὴν ἄφιξιν. 115, 21.

In a number of other cases the regular patterns are present, but violated.

Form 2. 5 (1, V, 1)

ὁ μὲν ταῦτα εἶπεν. 42, 15.
τὸ ἀριστερὸν λάθρα ἔπεμψεν. 72, 10–11.

Form 4. 64 (O, VI, 2. 1, V, 2)

ἐχρῆτο οὐδενὶ λόγῳ. 535, 19–20.
οἱ πρέσβεις τοσαῦτα εἶπον. 114, 5.

Still other cases may be brought to conformity to the regular forms by introducing elision against the manuscripts.

Form 2. 33 (O, X, 1. 1, VII, 1)

ξυνενεχθέντα ἐρῶν ἔρχομαι. 45, 13–14.
Λαζοῖς δοκοῦντα εἴη. 290, 15.

Form 4. 32 (O, X, 2. 1, VII, 2)

τὰ ξυνοίσοντα ἐς βουλὴν ἔρχεσθαι. 395, 3–4.
ταῦτα ποιητέα εἴη. 30, 12.

Two cases occur in which an elision as printed in the text may be removed to produce a regular form.

Γετικὰ ἔθνη ταῦτ' ἐκάλουν. 311, 10.
(*ταῦτα ἐκάλουν.*)
ἐζήτουν ἐφ' ᾧ κτείνωσι. 126, 22–23.
(*ἐπὶ ᾧ κτείνωσι*, making a 4 form.)

B. Aphæresis. There are 207 cases in which hiatus could be avoided by aphæresis. It is not certain whether the possible aphæresis should be consistently avoided, but this would seem to be the safest course. Reading these cases as printed in the text, we find the following cases to be added to the regular list.

Form 2. 151 (2, VI)

ἐρωμένου ἐμπίμπλασθαι.	18, 4.
πολεμίᾳ ἐδύναντο.	43, 23.

Form 4. 21 (4, V)

στρατοπεδευόμενοι ἐπορεύοντο.	38, 9–10.
μεταποιεῖσθαι ἐξεπισταμένος.	319, 11–12.

There are 17 additional cases in which the regular patterns are present but violated (except in one case).

Form 2. 2 (O, V, a, 1. 5, II)

βασιλεῖ ἐς τὰ μάλιστα.	347, 19.

Form 4. 15 (O, VI, 2. 1, V, 2. 3, III, b)

τῇ Ἀντωνίνῃ ἐντυχεῖν λάθρα.	139, 1–2.
διαβοήτῳ ἐς ἄγαν οὔσῃ.	327, 9.

C. Crasis. Here, as in the case of aphæresis, there seems no warrant to consistently read with crasis in order to avoid hiatus. As the text stands there are 18 cases where crasis might be reasonably expected. The following are regular:

Form 2. 6 (1, IV, a, 1. O, V, b, 1)

ποιεῖ τὰ ἐγκλήματα.	368, 4–5.

Form 4. 4 (1, IV, a, 2. O, V, b, 2)

ἐσήμηνε τὰ ἐσόμενα.	193, 12–13.

In 6 more cases the regular patterns are present but violated; (O, VI, 1. O, VI, 2. 1, V, 1)

IV. Various possibilities. There are 42 cases of the type *ἐπ' αὐτοὺς ἦλθεν*; the frequent occurrence of this type suggests that the regular pattern of the 2 form should be here recognized, by stressing the preposition[1] (in every case an elided form), and counting out the

[1] The placing of an ictus on such forms as *ἐπ'* is easily paralleled in the Political Verses; *ὑπ'* bears an ictus in Tzetzes I, 222 (ed. Kiessling); so *ἀπ'* in VII, 260. It may also be noted that the full form *ἐπί, παρά* etc. are often stressed on the first syllable in the Political Verses; so *παρά* is stressed on the first syllable in Constantinus Manasses (Corpus Scr. Hist. Byz.) v. 2787; so *ἐπί* in v. 1047.

accent of the pronoun; in 7 cases the first personal pronoun is present; in all the rest are forms of *αὐτοῦ*.

Form 2. 42 (0, VIII)

παντὶ τῷ στρατῷ ἐπ' αὐτοὺς ἦλθεν.	184, 6–7.
στρατὸν ἀγείρας ἐπ' αὐτοὺς ᾖει.	10, 12–13.
τὰ παῤ ἡμῶν φίλια.	353, 19.

There are 41 cases which should be considered of the same type as *ἐπ' αὐτοὺς ἦλθεν*; in all these a written accent on a pronoun is subordinated, while a preceding monosyllable forms the first thesis of the clausula (a dissyllable occurs once—*ὑπέρ*); in some cases this thesis coincides with a written accent; in some a proclitic must be stressed.

Form 2. 41 (0, IX)

Ῥωμαίων προκαλουμένων πρὸς αὐτὰς, θήσονται.	279, 20–21.
τὴν γνώμην ξὺν αὐτοῖς ἔθεντο.	133, 23–24.
τῷ στόλῳ εἰς ἡμᾶς ἦκε.	414, 21.
ἀπαξιοῦν ὑπὲρ αὐτῆς θνήσκειν.	405, 18.
τὰ ξυνοίσοντα ἐργάζεσθαι τοῖς αὐτοῦ πράγμασιν.	223, 4–5.
δυνατώτατος ὢν ἡμεῖς ἴσμεν.	125, 18.

Cases like the above, but more violent are the following.

Form 2. 75 (0, VII, 1. 1, VI, 1. 5, II)

ἐς φυγὴν ὥρμητο.	28, 22.
(Occurs 16 times.)	
οὐκ ἐς μακρὰν δείξουσιν.	33, 19–20.
(Occurs 4 times.)	
φρούριον οὐκ ἀσφαλὲς ἦν.	526, 12.
(Count out *ἦν*.)	
νηῶν οὐ παρουσῶν σφίσιν.	300, 1–2.
(Stress *οὐ* and count out *σφίσιν*.)	
ἐν σπουδῇ εἶχε.	286, 22.
(Occurs 7 times.)	

Form 4. 5 (0, VII, 2.)

ἐν παρασκευῇ ἔχειν.	287, 14.
ἐς τὸ ἀκριβὲς ἤσκητο.	31, 8.

There remain 46 cases in which regularity may be found in various ways; these cases follow.

μεταβαλεῖν ἐς τὸ κυάνεον παντελῶς ἴσχυσεν. 341, 14.

Form 4 may be read if *κυάνεον* be made a trisyllable with synizesis.

γενόμενοι κατὰ κορυφὴν βάλλωσιν. 471, 18.

The Political Verses, as noted above, show cases of the dissyllabic prepositions bearing an ictus on the first syllable; by reading *κάτα* in this case, there appears the pattern of the 4 form, although it is violated by the accent on *κορυφὴν*. A similar case is the following:

ἐπέμποντο ἀνὰ πᾶν ἔτος. 329, 7.

Cases of the following type are puzzling:

ξὺν ἡμὶν ἐνταῦθά εἰσι. 449, 21–22.
ἀοίκητος χώρα ἐπὶ πλεῖστον ἐστι. 187, 19–20.

In the following reading *αὐτοῦ* produces either form 2 or 4, according as *τὴν* is stressed or not.

τὴν μητέρα τὴν ἑαυτοῦ ἔκτεινεν. 85, 12.

In several cases a plain 2 form is produced by reading iota as a consonant.[1]

ἐπίπροσθεν ἰόντα. 241, 18.
τὸ λοιπὸν ξυμβιοτεύειν. 207, 19–20.

This license may not be justly assumed for such an early period as that of Procopius, but at a later period it must have been very common, as is shown by its frequent occurrence in the Political Verses of Demetrius Zenus (16th. century).

After exhausting all possibilities, there still remain a number of irregular cases.

Form 0. 227 (0, I)

καὶ Λαζικὴν ἐνδιδοὺς ἅπασαν. 224, 24.
οὔπω καὶ νῦν πάρεισι. 94, 16.

Form 1. 159 (0, II. 1, I)

λόγῳ οὐδενὶ Ῥωμαίους ἔχειν 53, 20.
τοσαῦτα μὲν οἱ πρέσβεις εἶπον. 220, 26.

Form 3. 73 (0, III. 3, I)

τούτου ἐλάσσονι διείργεσθον ἀλλήλαιν. 308, 23–24.
ἅπαντες Χριστιανοὶ γεγενημένοι. 78, 17–18.

Form 5. 14 (5, I)

ἐπιθήσεσθαι διενοοῦντο. 118, 24.
βαρβαρικώτερον ἐσκεδασμένοι. 501, 22–23.

The final result reached is this: as the text stands, a uniform conformity to the cursus law can not be found in Procopius. There are too many cases which seem to admit of no explanation (12.63+%), while the percentage of perfectly plain regular cases is too small

[1] This license is commonly assumed in reading the Latin accentual cursus.

(68.9 + %) to justify the expectation that the law will be consistently applied. The answer can not be finally made to the question proposed above as to the exact extent of the law's application in Procopius, until the manuscript tradition is thoroughly reviewed with the cursus law in view. Provisionally, however, it may safely be maintained that the cursus law is plainly operative in Procopius, but its application is not thorough.

There are numerous indications of wilful neglect of the cursus rhythm in Procopius' language which show that a regular cursus was not sought by him. For example, a sentence is often closed with the phrase *ἐρῶν ἔρχομαι*, which makes a perfectly regular form of clausula impossible. Even where the 4 form is suggested, as *ἐσέβαλεν, ἐρῶν ἔρχομαι* (164–22), the written accent of *ἐρῶν* standing in arsi plainly violates the rhythm. In such a case as *ἐστάλη, ἐρῶν ἔρχομαι* (365–6, 7), there is absolutely no trace of a regular form. It is a plain case of neglect of the cursus; for a similar formula was at hand which makes a perfect 2 form: *ἔρχομαι λέξων*, found in Zosimus, V, 38. The case becomes absolutely certain when it is added that Procopius has as clausulæ *λέξων ἔρχομαι* (327–2) and *φράσων ἔρχομαι* (307–3), either of which would make a perfect 2 form if the order were reversed. Other phrases which are frequently found transgressing the law are the following:

ἐγὼ δηλώσω.	84, 3; 422, 12 etc.
ἐποίει τάδε.	15, 6; 509, 16 etc.
οὐδενὸς ἧσσον.	157, 14; 158, 22 etc.
ἐς ἔδαφος καθεῖλεν.	60, 17; 248, 24–25 etc.

All these phrases, except *οὐδενὸς ἧσσον*, would make a perfectly regular form of clausula if the order of words were reversed.

Other cases of a like character are added to these to make it clear that this repeated violation of the cursus rhythm is not limited to set phrases alone. In each case a reversal of order would make a regular form.

δόξης ἤθελεν.		458, 8–9.
ἐχώρουν πρόσω.		512, 21.
(Cf. *πρόσω ἐχώρουν.*	91–16.)	
ἁπάντων εἶεν.		24, 9.
ἐκώλυεν ὁ νόμος.	(*ἐκώλυεν*)	49, 4.
μένειν εἴασεν.		70, 6.
πεινῶσιν ἐπιθῶνται.		71, 3.
Ῥωμαῖοι ἔσχον.		74, 30.
βασιλεῖ φέρουσιν.		77, 8.
κατορθοῦν ἅπαντας.		87, 10.
ξυμβαίνει εἶναι.		101, 20.

It is impossible to suppose that the order in such cases is a perversion by the manuscript tradition of an order which originally conformed to the cursus forms; their occurrence is entirely too common to allow such an explanation. It is rather necessary to believe that Procopius wilfully neglected the cursus rhythm in many of his clausulæ—a neglect which is doubtless to be explained by his constant imitation of Herodotus and Thucydides. Nevertheless, the cursus rhythm was plainly known to him, and he should be classed as a writer who consciously sought that rhythm without insisting on producing it with unchanging regularity.

APPENDIX

The tables here given contain statistics of all the clausulæ before periods in the Persian War of Procopius of Cæsarea, and set forth the data on which the foregoing conclusions are based. The clausulæ are separated into forms as marked by written accents alone; after this formal classification the certainly irregular forms are separated from those which are only apparently so, and the final result of this sifting process is given in the general summary at the end.

FORM 0

Total of this form 920.

	No Hiatus	Weak Hiatus	Elision avoided	Elision introduced	Aphæresis avoided	Crasis avoided	TOTALS
I No regular pattern present	166	59				2	227
II Pattern of form 1 to be read	4						4
III Pattern of form 3 to be read	11						11
IV Various possibilities	14	1					15
V Pattern of regular forms—plain							
a. Weak written accent in arsi							
1. Form 2	102	9	4		1		116
2. Form 4	4	1	3				8
b. Weak written accent after last thesis							
1. Form 2	6	5	5			2	18
2. Form 4	8	5	1			2	16
VI Pattern of regular forms—violent							
1. Form 2	105	27				3	135
2. Form 4	93	46	38		8	2	187
VII Pattern of regular forms—stress on proclitic							
1. Form 2	52	16	1				69
2. Form 4	4	2					6
VIII Type ἐπ' αὐτοὺς ἦλθεν	42						42
IX *Like* type ἐπ' αὐτοὺς ἦλθεν	29	10	2				41
X Pattern of regular forms—introducing elision							
1. Form 2	—			10			10
2. Form 4	—			14			14
XI Pattern of form 4—restoring elided vowel	—		1				1
	640	181	55	24	9	11	920 = 22.4 + %

FORM 1

Total for this form 475.

	No Hiatus	Weak Hiatus	Elision avoided	Elision introduced	Aphaeresis avoided	Crasis avoided	TOTALS
I No regular pattern present	117	22	7		8		154
II Pattern of form 3 to be read	2	3					5
III Various possibilities	15	4					19
IV Pattern of regular forms—plain							
a. Weak accent in arsi							
1. Form 2	19	2	13			4	38
2. Form 4	15	1	1			2	19
3 Form ὧδέ πῃ εἶχεν	1	5					6
b. Weak accent after last thesis							
Form 4	1						1
V Pattern of regular forms—violent							
1. Form 2	15	4	5			1	25
2. Form 4	102	30	26		6		164
VI Pattern of regular forms—stress on proclitic							
Form 2	2						2
VII Pattern of regular forms—introducing elision							
1. Form 2				23			23
2. Form 4				18			18
VIII Pattern of form 2 – restoring elided vowel			1				1
	289	71	53	41	14	7	475 = 11.5+ %

FORM 2.

Total of this form 2197.

	No Hiatus	Weak Hiatus	TOTALS
I Perfect	1550	141	1691
II Enclitics and prolitics in arsi	31	9	40
III Weak accent used as thesis	52	7	59
IV Heavy accent preceding first thesis	57	8	65
V Elision avoided			191
VI Aphæresis avoided			151
			2197 = 53.6+%

FORM 3.

Total of this form 94.

	No Hiatus	Weak Hiatus	Elision introduced	Aphæresis avoided	TOTALS
I No regular pattern present	41	8		8	57
II Various possibilities	12				12
III Form 4 to be read					
a. Plain	1				1
b. Violent	8	2		1	11
IV Elision introduced			13		13
					94 = 2.2+%

FORM 4.

Total of this form 387.

	No Hiatus	Weak Hiatus	TOTALS
I Perfect	275	21	296
II Enclitics and proclitics in arsi	8	6	14
III Heavy accent preceding first thesis	18		18
IV Elision avoided			38
V Aphæresis avoided			21
			387 = 9.4+%

FORM 5.

Total of this form 25.

	No Hiatus	Weak Hiatus	Elision introduced	Aphæresis avoided	TOTALS
I No regular pattern present	12			2	14
II Form 2 to be read–stress on proclitic	3			1	4
III Elision introduced			7		7
					25 = .6+%

GENERAL SUMMARY.

		No Hiatus	Weak Hiatus	Involving Elision Aphaeresis Crasis	TOTALS	
I Regularity Plain	Form 2 .	1818	186	384	2388	2827
	Form 4 .	330	34	75	439	
II Regularity Violent	Form 2 .	248	57	47	352	753
	Form 4 .	207	80	114	401	
III Regularity Appar. Impossible		394	97	27	518	
		2997	454	647	4098	

518 = 12.63+% apparently show no trace of regularity.
2368 = 57.7+% show perfectly plain regularity, omitting all cases involving elision, aphæresis and crasis.
2827 = 68.9+% show perfectly plain regularity, including all cases involving elision, aphæresis and crasis.

The classes in the above table are represented in the preceding tables as follows:

Class I	Class II	Class III
Form 0, V entire	Form 0, VI	Form 0, I
„ 1, IV „	„ 0, VII	„ 0, II
„ 2 „	„ 0, VIII	„ 0, III
„ 3, III, a	„ 0, IX,	„ 0, IV
„ 3, IV	„ 0, X	„ 1, I
„ 4, entire	„ 0, XI	„ 1, II
„ 5, III	„ 1, V	„ 1, III
	„ 1, VI	„ 3, I
	„ 1, VII	„ 3, II
	„ 1, VIII	„ 5, I
	„ 3, III, b	
	„ 5, II	

PLATE I

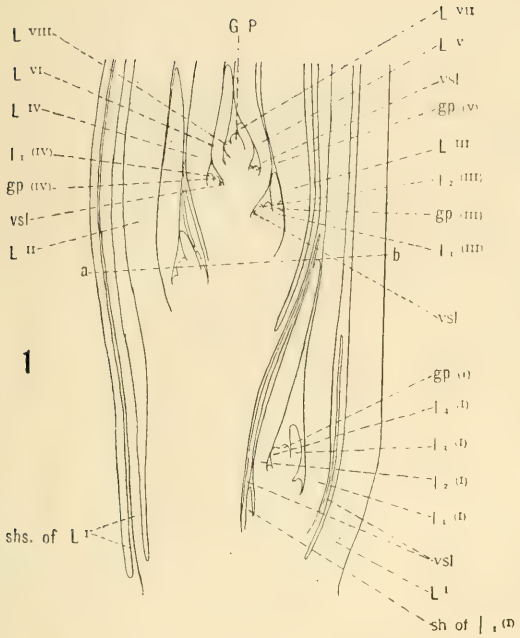
Figure 1.—Longitudinal section of stem-apex, showing growing-point and manner of development of leaves and axillary buds; L^{I}, L^{II}, L^{III}, &c., primary leaves; $l_1^{(I)}$, $l_2^{(I)}$, &c., $l_1^{(II)}$, $l_2^{(II)}$, &c., leaves of axillary buds of L^{I}, L^{II}, &c.; *G P*, main growing-point of stem; $gp^{(V)}$, $gp^{(IV)}$, &c., growing-points of axillary buds; *ab*, line where such a cross section as is represented in Plate VII, figure 43, might be cut perpendicular to plane of paper. × 30.

Figure 2.—Sketch from living specimen, showing vegetative branch system in a young stage; *I*, *II*, *III*, *IV*, &c., primary leaves. ½ natural size.

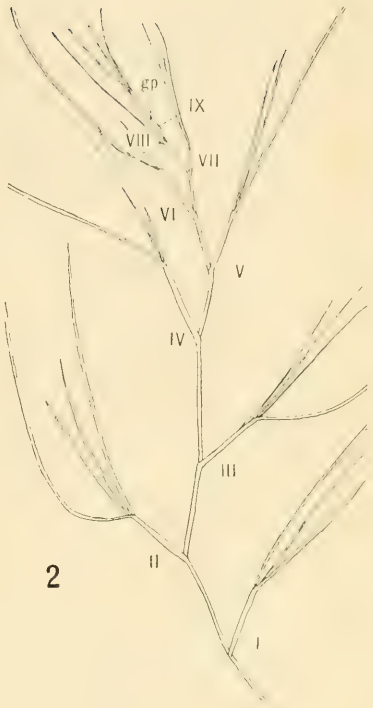
Figure 3.—Cross section of axial bundle of stem, showing endodermis, sieve tubes, central cavity formed by disorganization of tracheae, &c. × 300.

Figure 4.—Cross section of stem. × 60.

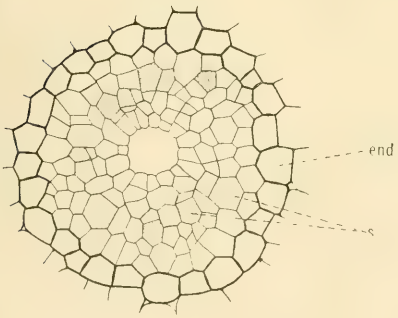
Figure 5.—Cross section of epidermis, cortex and endodermis of stem. × 212.


G P
L VIII
L VI
L IV
I 1 (IV)
gp (IV)
vsl
L II
a
b
L VII
L V
vsl
gp (V)
L III
I 2 (III)
gp (III)
I 1 (III)
vsl
gp (I)
I 2 (I)
I 1 (I)
I 2 (I)
I 1 (I)
vsl
L I
sh of I 1 (I)
shs. of L II

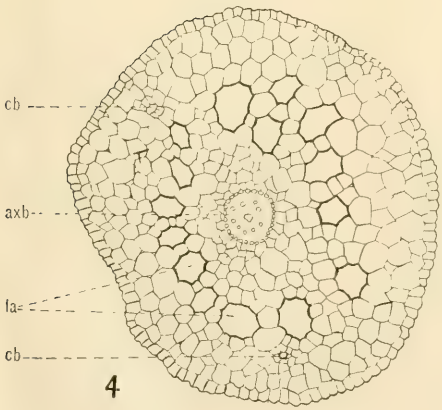
1


gp
IX
VIII
VII
VI
V
IV
III
II
I

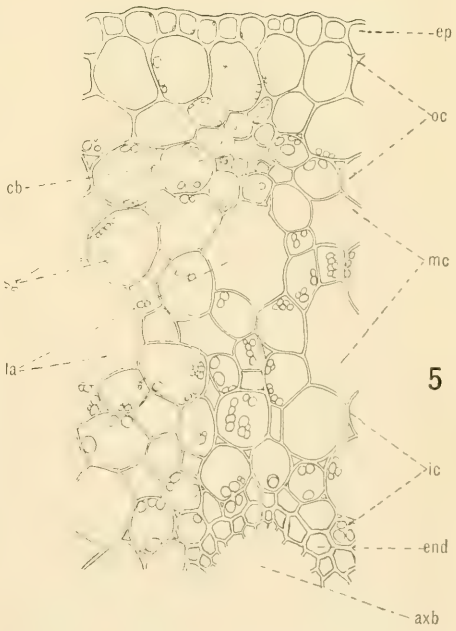
2


end
c

3


cb
axb
fa
cb

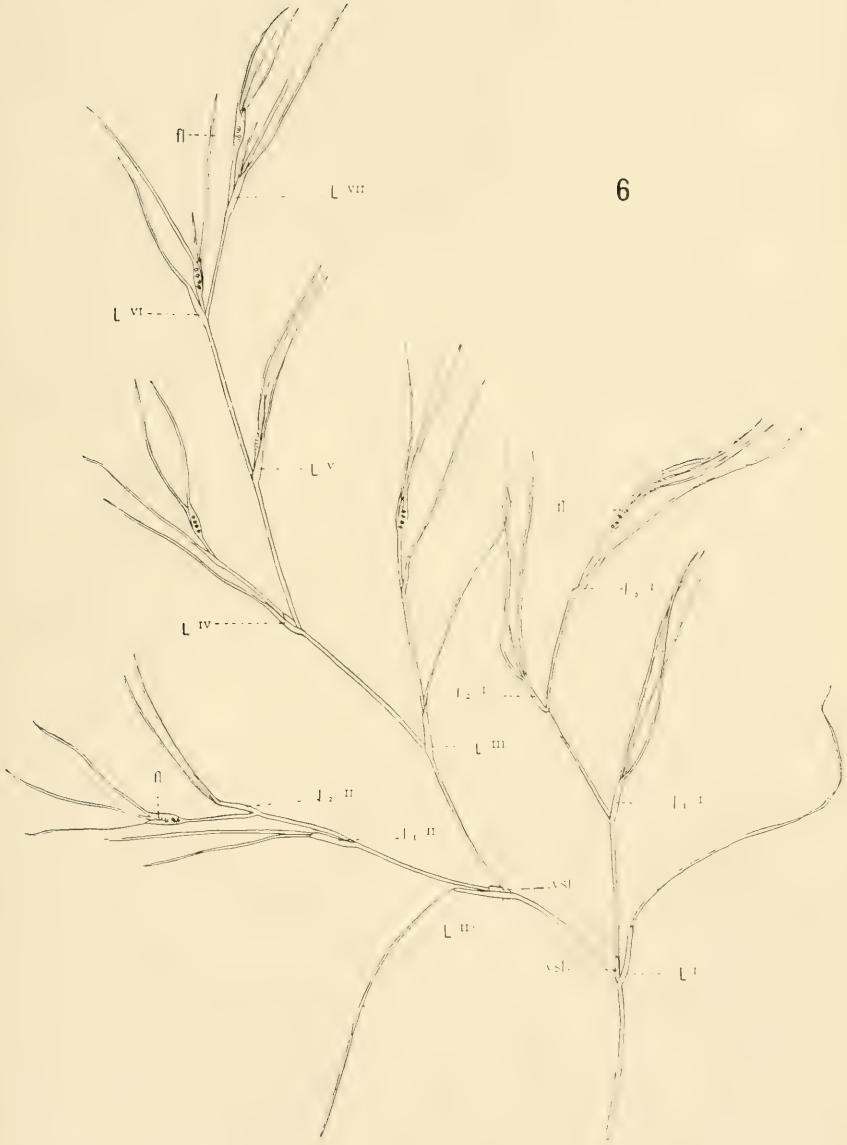
4


ep
oc
cb
mc
fa
ic
end
axb

5

PLATE II

Figure 6.—Sketch from living specimen, showing vegetative branch system in a mature stage, just previous to the appearance of flowers. Abbreviations as in figure 1. ½ natural size.



6

PLATE III

Figure 7.—Photomicrograph of cross section of stem, showing axial bundle, endodermis, cortex, lacunae, and epidermis. × 30.

Figure 8.—Photomicrograph of cross section of stem, axillary bud and subtending leaf; showing axillary scales, vegetative scale leaf surrounding axillary bud, secretion cells, &c. × 25.

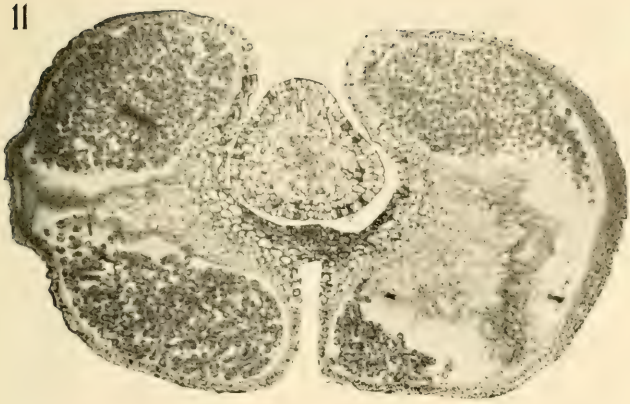
Figure 9.—Photomicrograph of cross section of rootstock; showing axial bundle, endodermis, cortex, lacunae, cortical bundles, epidermis, and starch-grains in cortex. × 50.

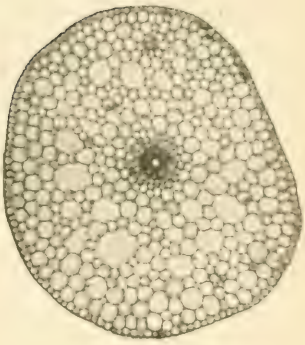
Figure 10.—Photomicrograph of cross section through node of rootstock; showing two roots developing, and epidermis of rootstock over each root becoming meristematic. × 35.

Figure 11.—Photomicrograph of cross section through rhachis; showing axial bundle with lacunae, &c., and surrounding stamen, with its two thecae, connective, &c. × 35.

Figure 12.—Photomicrograph of longitudinal section through end of rhachis; showing its blunt apex and various sections of pistils and anthers. × 35.

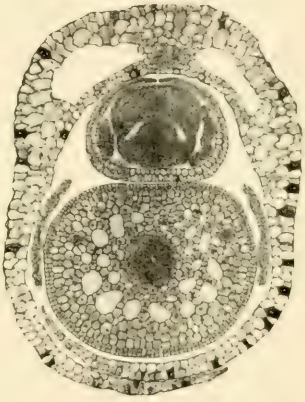
11



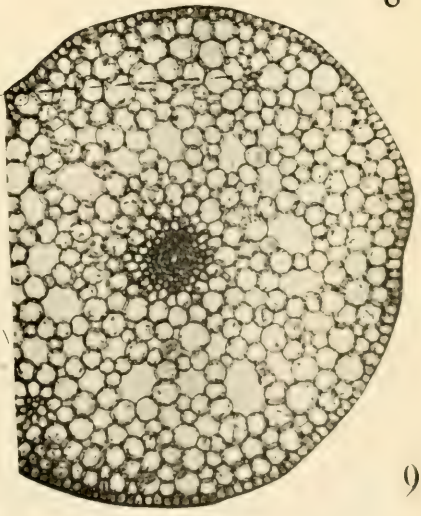


7

12



8



10

9

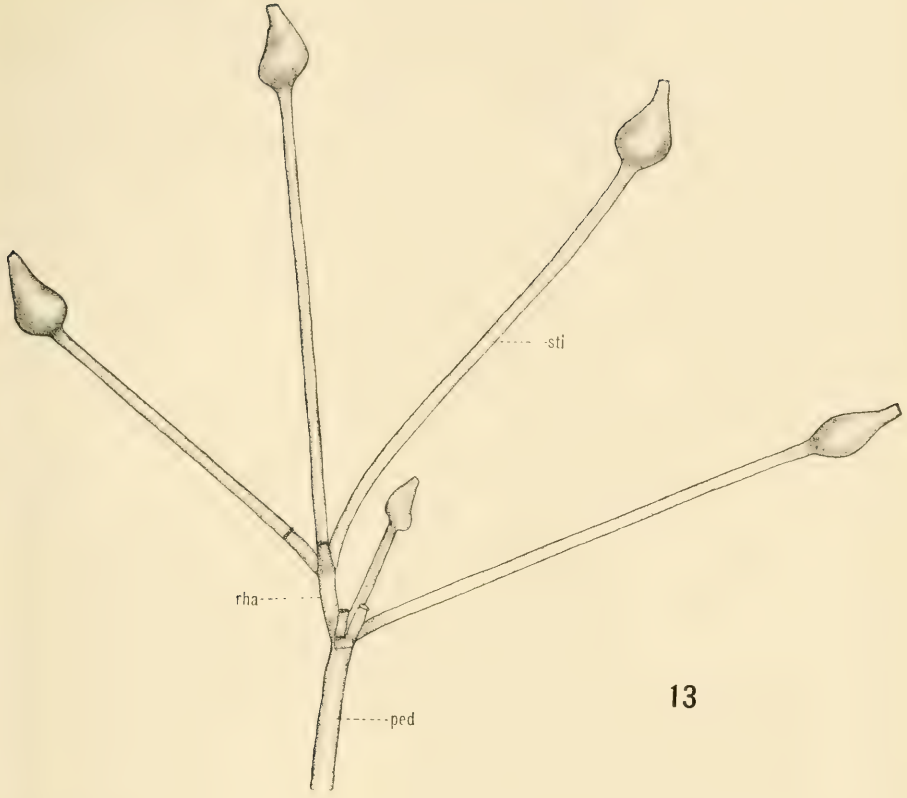
PLATE IV

Figure 13.—Drawing of cluster of fruit about mature. × 5.

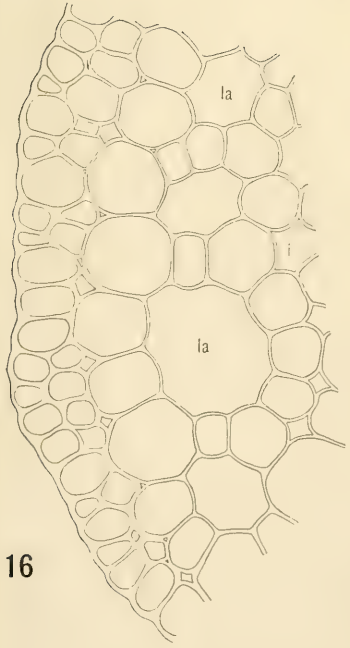
Figure 14.—Surface view of epidermis of stipe (young stage); showing secretion cells. × 212.

Figure 15.—Cross section of mature stipe; showing epidermis, cortex, and axial bundle; intercellular spaces and lacunae stippled; x = apparently halved epidermal cells. × 185.

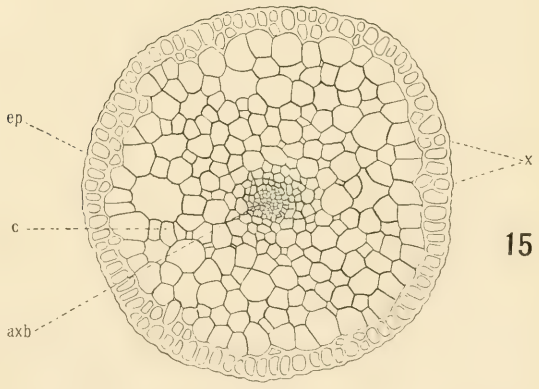
Figure 16.—Part of cross section of stipe, showing strengthened epidermis, part of cortex, lacunae and small intercellular spaces. × 212.



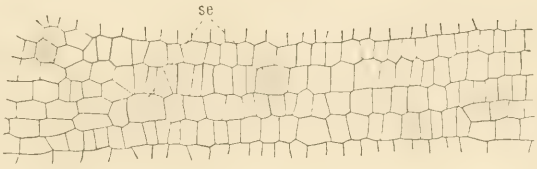
13



16



15



14

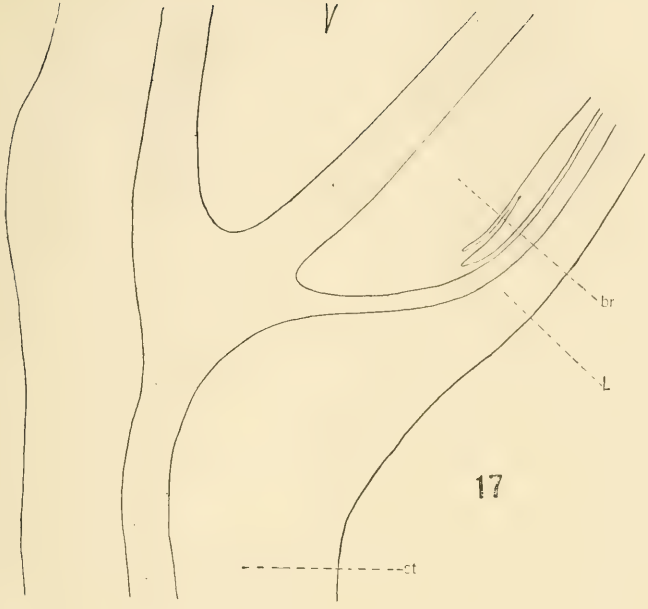
PLATE V

Figure 17.—Diagrammatic representation of median longitudinal section through stem and axillary branch; *L*, subtending leaf; vascular portions stippled. × 212.

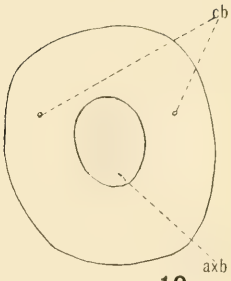
Figure 18.—Diagrammatic representation of median longitudinal section through stem at base of inflorescent branch system, showing the course of the vascular bundles. Vascular portions stippled. × 212.

Figures 19–24.—A series of cross sections through stem beginning just below point of leaf insertion and extending up into leaf, showing course of cortical bundles from stem to leaf and independent origin of new cortical bundles in the stem. × 35.

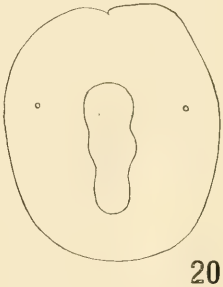
Plate V



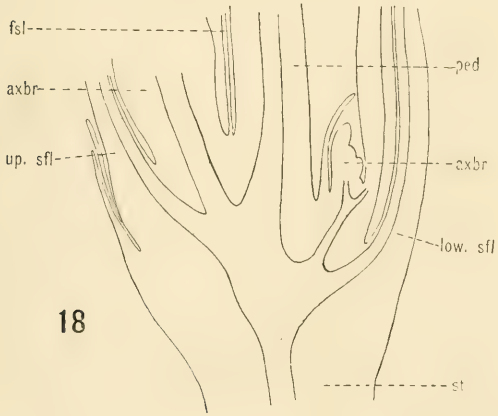
17



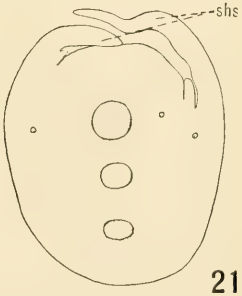
19



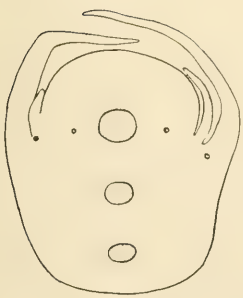
20



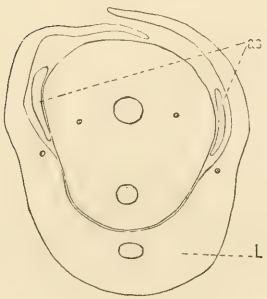
18



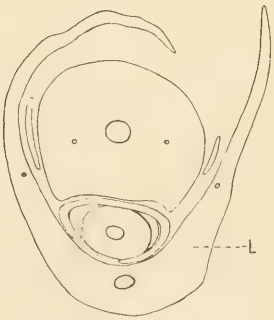
21



22



23



24

PLATE VI

Figure 25.—Photomicrograph of longitudinal section through stem apex; showing growing point and leaves in successive stages of development, similarly as in Pl. I, fig. 1. × 40.

Figure 26.—Photomicrograph of apical portion of leaf, not quite mature; showing marginal teeth. × 35.

Figure 27.—Photomicrograph of cross section of root; showing epidermis, exodermis, cortex, endodermis and axial vascular bundle. × 60.

Figure 28.—Photomicrograph of young leaves surrounding growing-point, dissected from living specimen. × 35.

Figure 29.—Photomicrograph of portion of epidermis near apex of root; showing trichoblasts (the darkly stained cells). × 40.

Figure 30.—Photomicrograph of surface of leaf treated with a five per cent solution of potassium hydroxide; showing epidermal secretion cells and central vascular bundle. The marginal teeth have been worn off. × 30.

Figure 31.—Photomicrograph of a cross section through a node of the stem showing the origin of a single root—the typical condition. In this figure the meristematic layers at the growing point of the root are clearly defined. × 35.

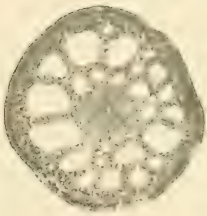
Figures 32 and **33.**—Photomicrographs of adjoining portions of a nearly median longitudinal section through the root apex, showing trichoblasts. (The root cap was slightly separated from the growing-point in preparation.) × 50.

Figure 34.—Photomicrograph of cross section of young peduncle, showing axial bundle, lacunae in cortex, &c. × 35.

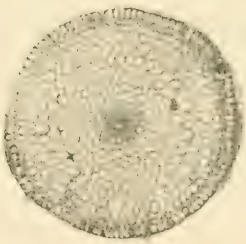
25

26

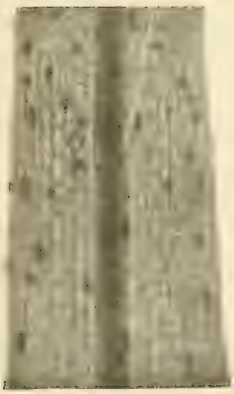
34



27

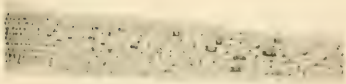


30



28

29



31

32

33

PLATE VII

Figure 35.—Sketch of flower bud; showing basal sheaths of subfloral leaves enclosing young flower. × 5.

Figure 36.—Sketch of portion of plant; showing horizontal rootstock and arrangement of roots and upright shoots. ½ natural size.

Figure 37.—Group of cells from vegetative scale leaf. × 162.

Figure 38.—Coleorrhiza from which young root has been forced out. × 10.

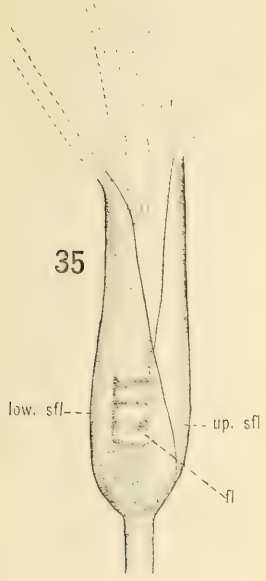
Figure 39.—Young leaf; showing teeth limited to extreme apex and comparatively large basal sheath. × 212.

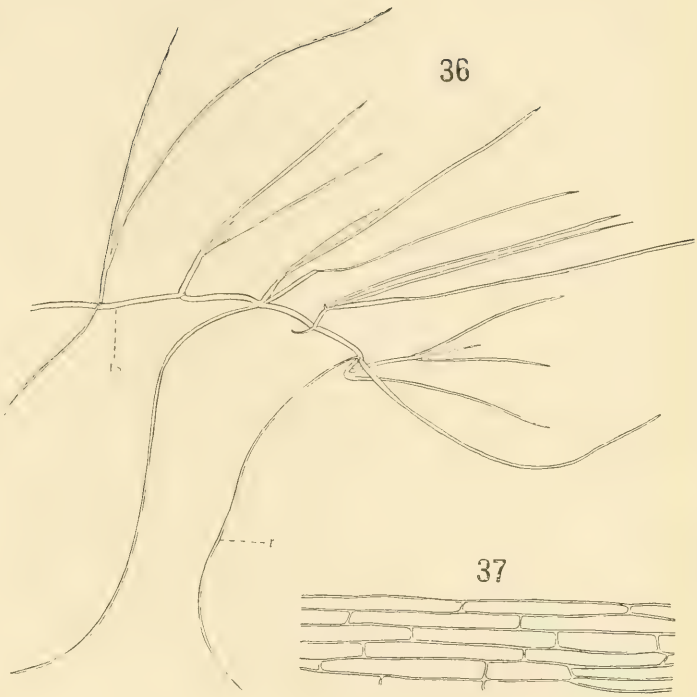
Figure 40.—The vegetative scale leaf, detached, and flattened out. × 5.

Figure 41.—Longitudinal section through young inflorescence, showing floral scale leaf developing in connection with the flowers. × 30.

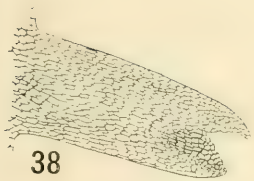
Figure 42.—Floral scale leaf *in situ*, close to young flowers. × 4.

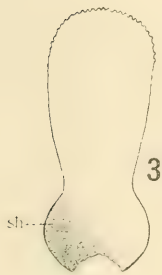
Figure 43.—Cross section through vegetative bud, a little below the region of the growing point, cut at about the level shown by the line *ab* in figure 1. Abbreviations as in figure 1. The line *ab* in this figure represents the plane perpendicular to the paper, in which a longitudinal section such as is shown in figure 1 would lie. × 65.

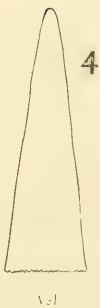

35
low. sfl
up. sfl
fl

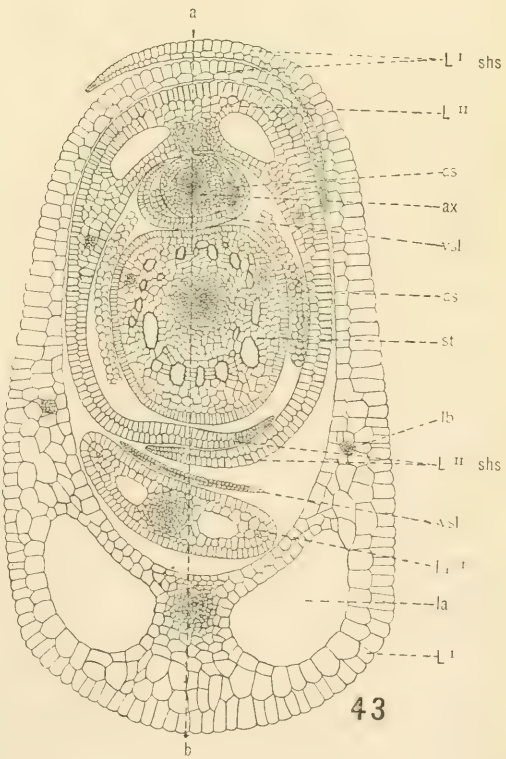

36
r

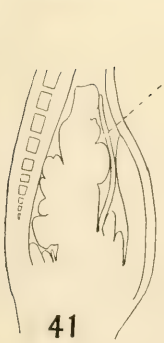
37


38


39
sh


40


a
L I shs
L II
cs
ax
cs
st
lb
L II shs
la
L I
b
43


fsl
41

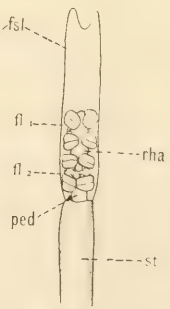

fsl
fl 1
fl 2
rha
ped
st
42

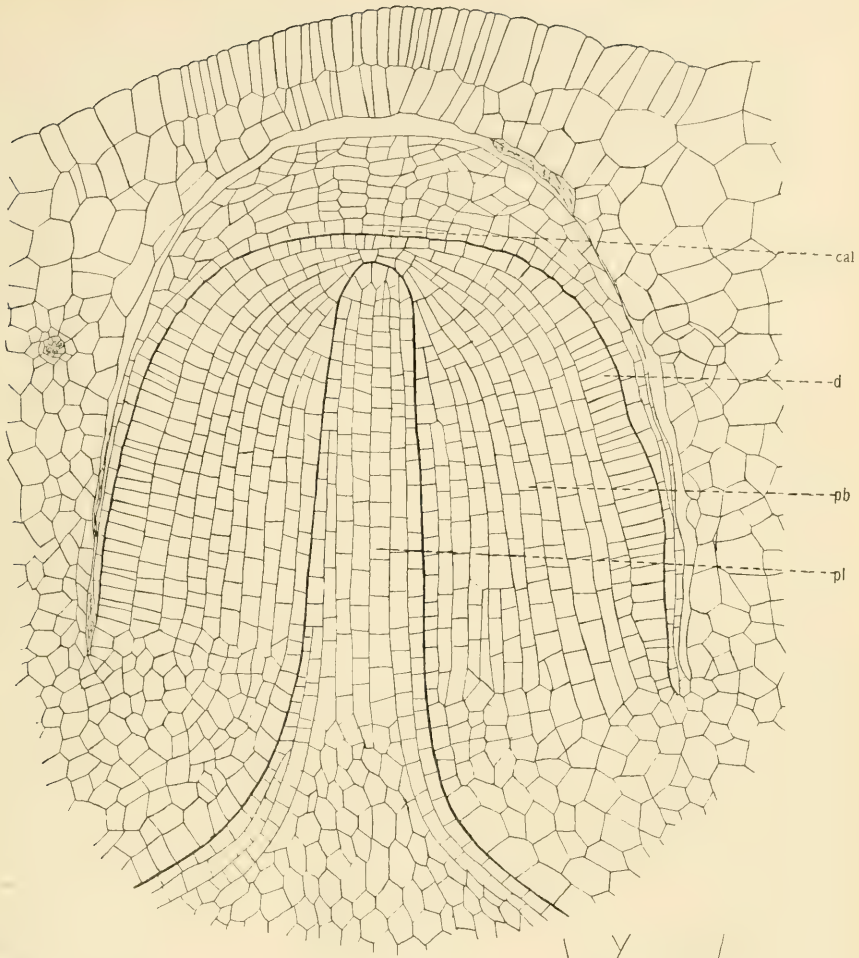
PLATE VIII

Figure 44.—Longitudinal section of young root still enclosed in the stem; showing its origin in the stem, the meristematic epidermis and subepidermis in the stem above root apex and the four meristematic layers in the root. × 210.

Figure 45.—Portion of rootstock and root; the latter showing coleorrhiza. × 6.

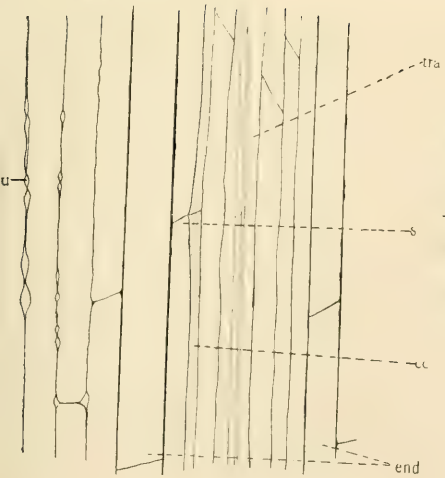
Figure 46.—Cross section of vascular bundle of root with endodermis; showing tracheae and sieve tubes. × 400.

Figure 47.—Longitudinal section of vascular bundle of root, also with endodermis and, to the left, three layers of cortical parenchyma; showing tracheae, sieve tube, companion cell and undulations in walls of cortical parenchyma. × 400.

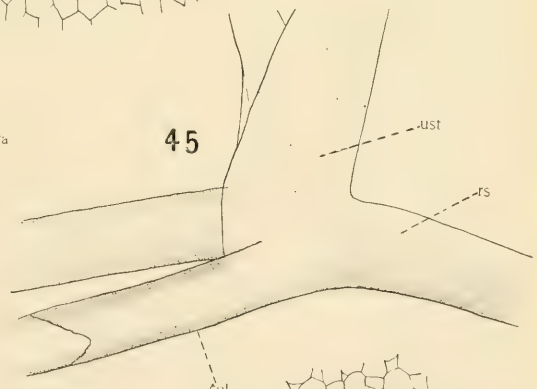


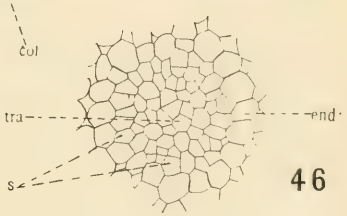
44

47



45





46

PLATE IX

Figure 48.—Surface view of cells from epidermis of root, showing root hairs developing from the trichoblasts. × 210.

Figure 49.—Rhachis with the two flowers; showing arrangement in the adult condition. × 12.

Figure 50.—Rhachis and young flowers; showing arrangement in young stage. × 30.

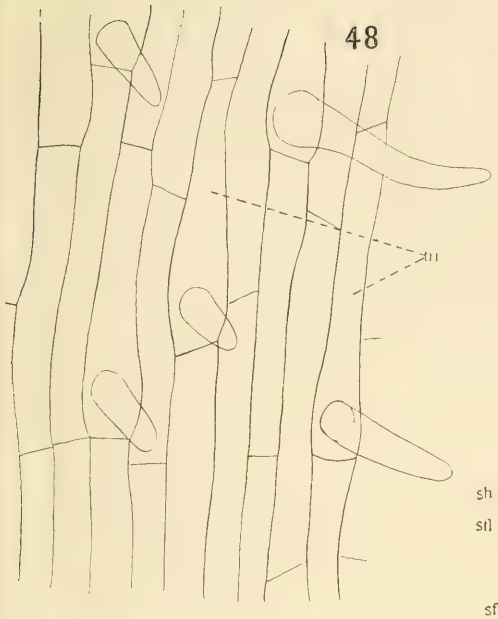
Figure 51.—Longitudinal section through nearly mature rhachis and flowers. × 20.

Figure 52.—Very young floral primordia. Stippled portions represent regions which will develop the flowers. × 210.

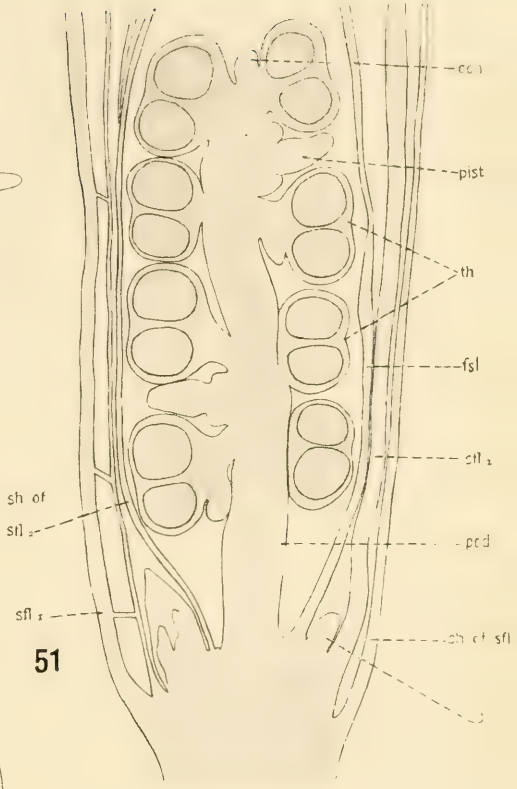
Figure 53.—Slightly older floral primordia. Stippled portions represent regions which will develop the flowers. × 210.

Figure 54.—Older floral primordia. Floral scale leaf appearing. × 210.

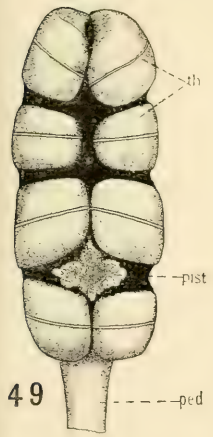
Figures 55 and **56.**—Successively older stages in floral development. In figure 56 the primordia of pistils and stamens appear well defined. × 60.



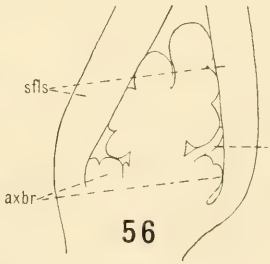
48



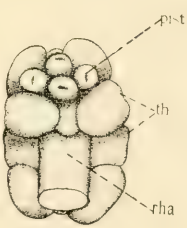
51



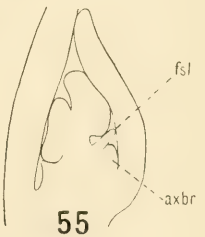
49



56

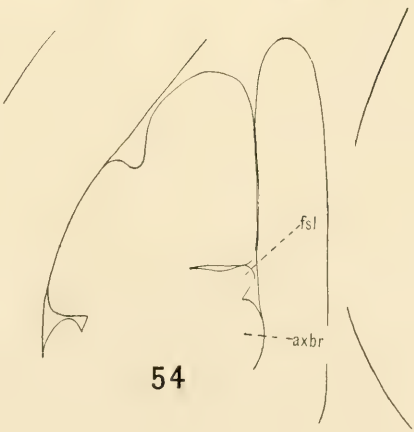


50

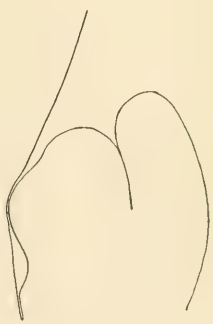


55

53



54



52

PLATE X

Figure 57, a and b.—Two views of a mature theca, the dotted triangular region representing the region of attachment to the connective. × 30.

Figures 58-66.—Median longitudinal sections illustrating development of the pistils.

Figure 58.—Section through flower rudiment; showing primordia of two pistils, an anther-connective at each side. × 75.

Figure 59.—Section of older stage; showing the beginning of the development of the stylar canal. × 75.

Figure 60.—Older stage. × 75.

Figure 61.—Older stage. One-sided development of the pistils commences. × 75.

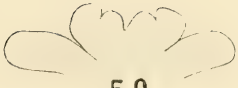
Figures 62 and **63.**—Stigma commences to form. Stylar canal well developed. × 75.

Figure 64.—Stigma assumes peltate form. Ovule and embryo-sac well developed. × 75.

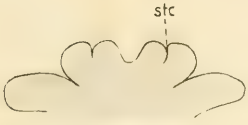
Figures 65 and **66.**—Development to approximately the mature form of pistil; showing the gradual oblique orientation of ovule. Figure 65, × 75; figure 66, × 37.

57

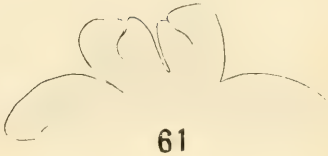
58



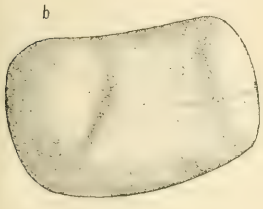
59

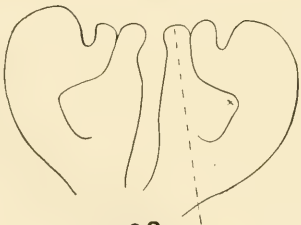


60



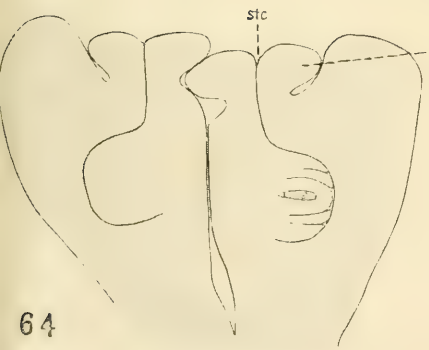
61



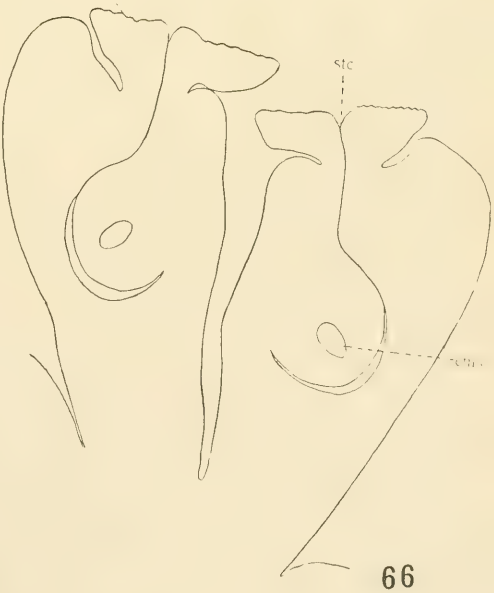


62

63



64



66

65

PLATE XI

Figure 67.—Cross section through young theca of a flower 0.2 mm. long, the measurement being taken in the direction of the dotted line shown in figure 68. Stippled cells represent the archesporial initials. × 600.

Figure 68.—Section of young flowers from which figure 67 is drawn, the actual length of each flower being about 0.2 mm. x marks the region represented in figure 67. Dotted line shows direction for measurement of the length of the flower. × 60.

Figure 69.—Cross section through slightly older theca of a flower 0.25 mm. long; showing division initiating development of septum, and also formation of the primary parietal layer. × 600.

Figure 70.—Section of flowers from which figure 69 is taken. x marks the region in figure 69. × 60.

Figure 71.—Cross section through theca of flower measuring about 0.3 mm. in length; showing sporogenous cells in the two sacs of the theca, two parietal layers, in places, and septum. × 600.

Figure 72.—Section of flowers from which figure 71 is taken. x marks the region shown in figure 71. × 60.

Figure 73.—Cross section through theca of a flower measuring 0.33 mm. in length; showing sporogenous cells in two sacs of theca, two parietal layers, and septum. × 400.

Figure 74.—Cross section through one of the sacs of a theca of a flower measuring about 0.5 mm. in length. Parietal layers often three in number. × 400.

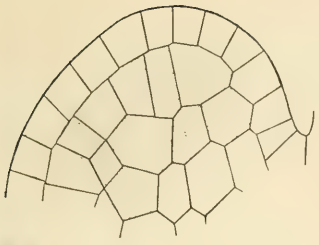
Figure 75.—Group of cells from cross section of pollen-sac; showing pollen mother-cells surrounded by the still intact tapetum. × 600.

Figure 76.—Portion of section through older pollen-sac; showing pollen mother-cells and dissolution of tapetal cells. × 600.

Figure 77.—Section of megasporangium showing two megaspore mother-cells and one parietal layer. × 375.

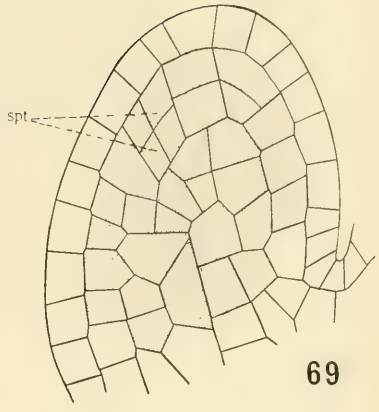
Figure 78.—Section of megasporangium showing four daughter-cells resulting from a double mother-cell, and also two parietal layers. × 400.

Figure 79.—Section of megasporangium; showing the four potential megaspores, the wall separating the two upper ones being approximately parallel to the plane of the paper. The three upper cells are all being resorbed. × 375.



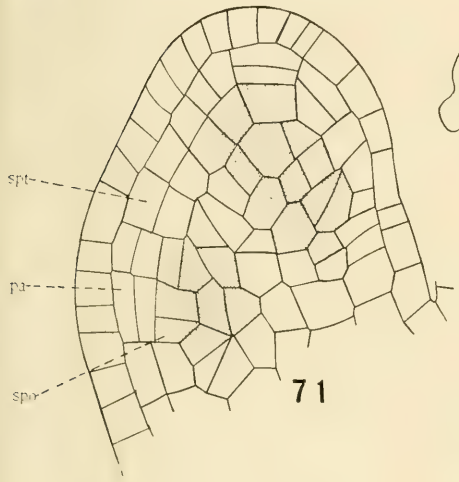
67

68



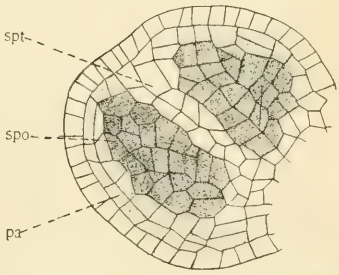
69

70

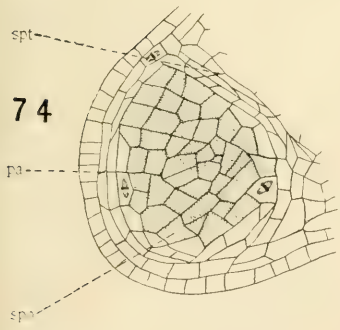


71

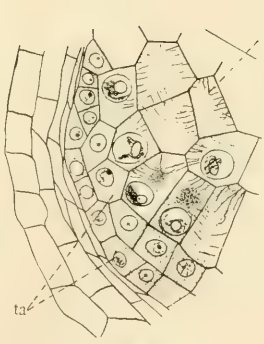
72



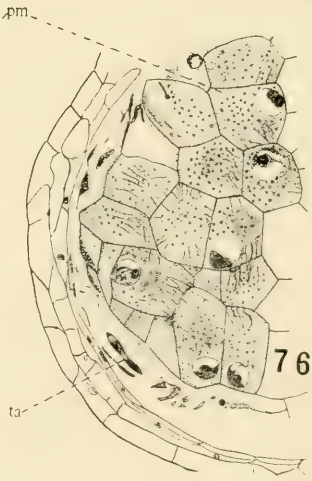
73



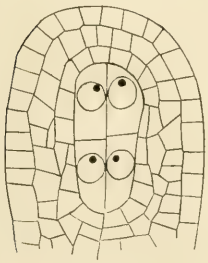
74



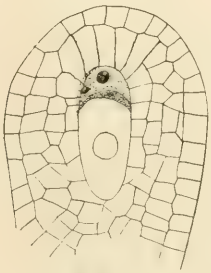
75



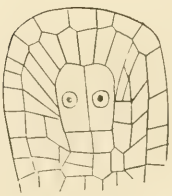
76



78



79



77

PLATE XII

Figure 80.—Section of megaspore mother-cell with surrounding cells, showing spindle of first reduction-division. Eight chromosomes were counted in this spindle, four of which are shown in the figure. × 800.

Figure 81.—Portion of section of megasporangium, showing the unusual condition of the four potential megaspores in a row, the two upper already being resorbed. Or, judging from the very indistinct wall separating the two lower cells and from their size, this may be a case where only three megaspores were formed, and the lowest has undergone the first division. × 800.

Figure 82.—Portion of section of megasporangium, showing omission of formation of wall between the two outer potential megaspores, these and the next lower becoming resorbed. × 800.

Figure 83.—Portion of section of megasporangium showing young embryo-sac with two nuclei; upper potential megaspores and part of surrounding tissue becoming resorbed. × 800.

Figure 84.—Young embryo-sac with four nuclei; showing also remnant of upper potential megaspores. × 800.

Figure 85.—Mature embryo-sac, showing synergidae, upper polar nucleus, egg, lower polar nucleus, and antipodals. × 800.

Figure 86.—The three antipodal cells lying in pouch at base of nature embryo-sac. × 800.

Figure 87.—Pollen mother-cell, synapsis stage. × 800.

Figure 88.—Young pollen-grain in tetrad before the dissolution of the tetrad wall. × 800.

Figure 89.—Pollen-grain just before formation of generative cell, showing enclosed starch grains and beginning of wall thickenings. × 800.

Figure 90.—Pollen-grain showing spindle preparatory to formation of generative cell. × 800.

Figure 91.—Cross section through middle of pollen-grain at stage shown in figure 90. × 800.

Figure 92.—Pollen-grain just after formation of generative cell. × 800.

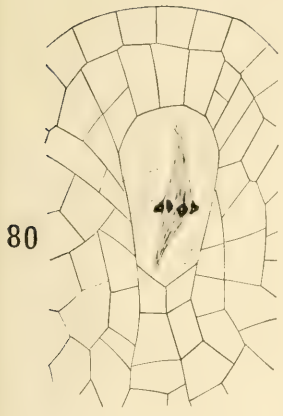
Figure 93.—Longitudinal section through almost mature pollen-grain, showing tube-nucleus and generative cell just previous to formation of male cells. × 400.

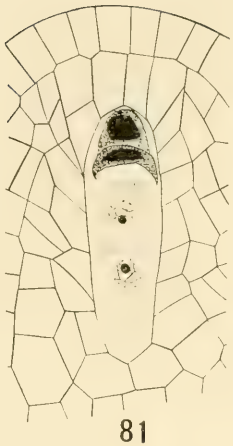
Figure 94.—Longitudinal section of mature pollen-grain showing the two male cells still united, and the degenerating tube-nucleus. × 375.

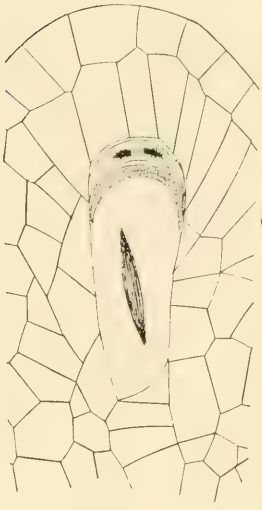
Figure 95.—Longitudinal section of mature pollen-grain, showing characteristic dumbbell shape. × 175.

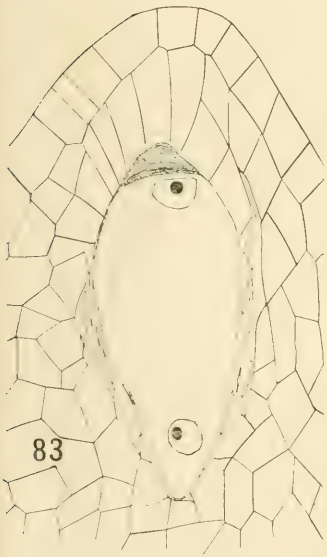
Figure 96, a and b.—Surface and profile views, respectively, of the pollen-grain wall thickenings, at mature stage. × 800.

Figure 97.—Pollen-grains, during the dissolution of the tetrad walls and formation of the pollen-grain wall. × 800.

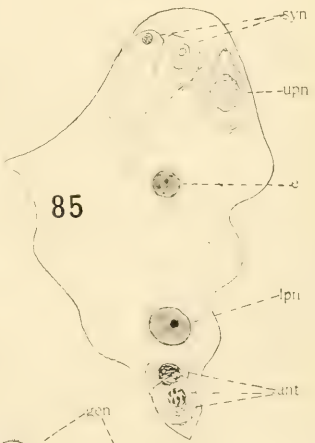

80

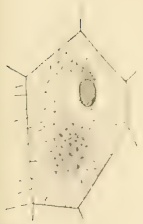

81

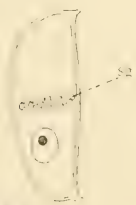

82


83

84


85
syn
upn
e
lpn
ant


87


88

89

90

92

93

94

86

95

97

96
b
a

91

PLATE XIII

Figure 98.—Three-celled proembryo of *Ruppia rostellata*, showing basal suspensor-cell and two smaller embryo-cells. After Murbeck. × 446.

Figure 99.—Nine-celled embryo of *Ruppia rostellata*, showing basal suspensor-cell and eight small embryo-cells. After Wille. × 340.

Figure 100.—Thirteen-celled embryo, showing division into three transverse segments of four cells each, and a large suspensor-cell with nucleus and cytoplasm in the characteristic position. × 800.

Figure 101.—Longitudinal section through older embryo, the heavy lines marking the outlines of the cells shown in figure 100. × 800.

Figure 102.—Longitudinal section of older embryo, showing the outlines of the original segments and the beginning of the formation of dermatogen, at least in the terminal segment, at left. × 800.

Figure 103.—Longitudinal section of embryo with a diameter of about 0.05 mm.; showing rather irregular segment lines, and globular form of embryo. × 800.

Figure 104.—Longitudinal section of embryo of a diameter of about 0.075 mm.; showing increase in size of all cells, but only a slightly greater number than in figure 103. × 800.

Figure 105.—Longitudinal section of embryo measuring about 0.085 mm. in length; showing commencement of elongation, and divisions in the terminal segment, at the left, indicating approach of cotyledonary development. × 300.

Figure 106.—Longitudinal section of embryo measuring about 0.135 mm. in length; segment limits obscure; apparently the terminal segment is commencing the formation of stem as well as cotyledon. Basal portion shows cells which go to form the rudimentary primary root. × 375.

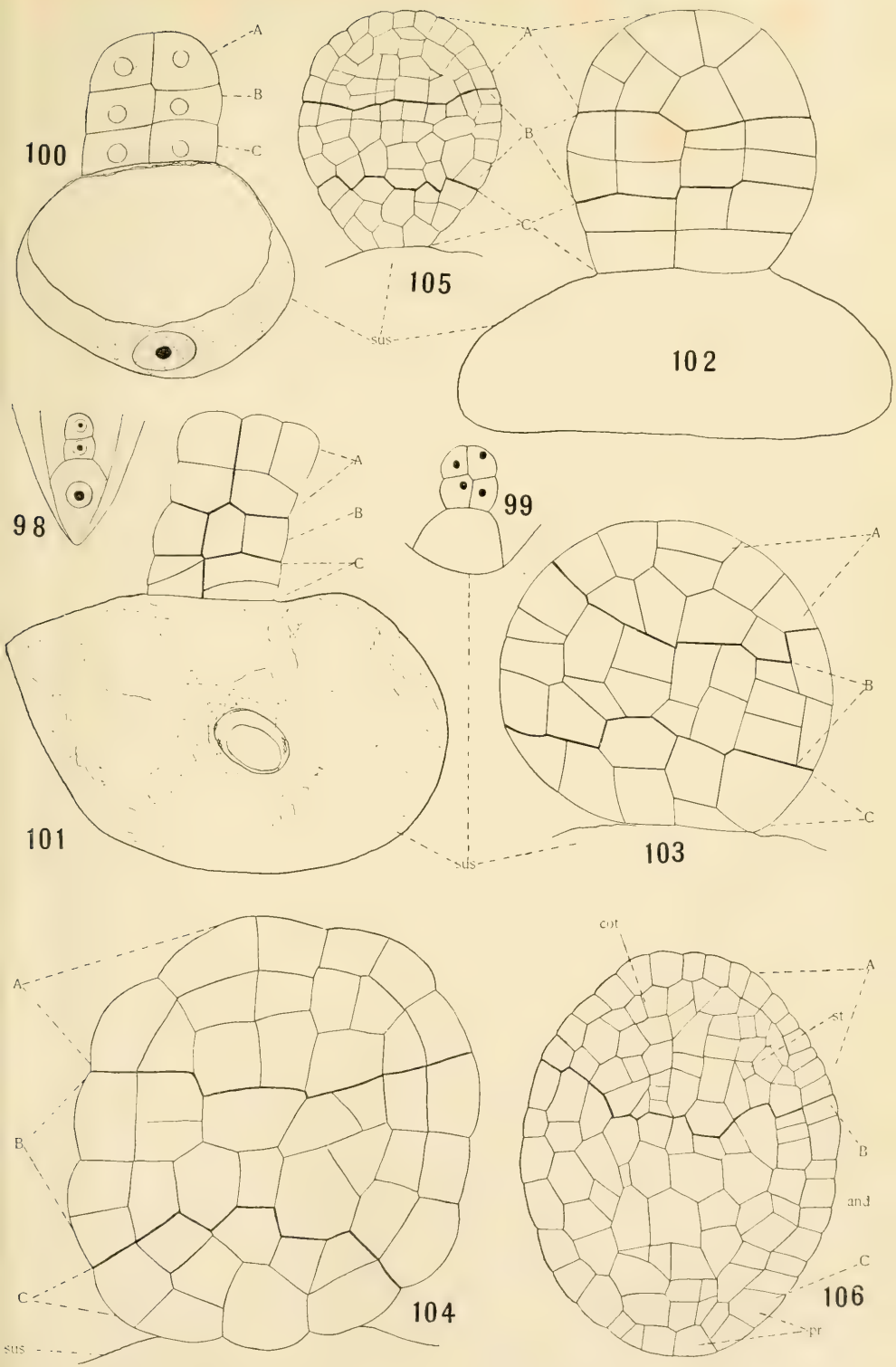

100
A
B
C
105
sus
102
98
99
101
103
104
106
cot
st
and
pr

PLATE XIV

Figure 107.—Part of longitudinal section through older embryo, showing origins of cotyledon and stem apex. × 375.

Figure 108.—Section of embryo from which figure 107 is taken. x marks the region figured. × 75.

Figure 109.—Longitudinal section of embryo measuring about 0.35 mm. in length; showing development of cotyledon and stem-apex or epicotyl. × 50.

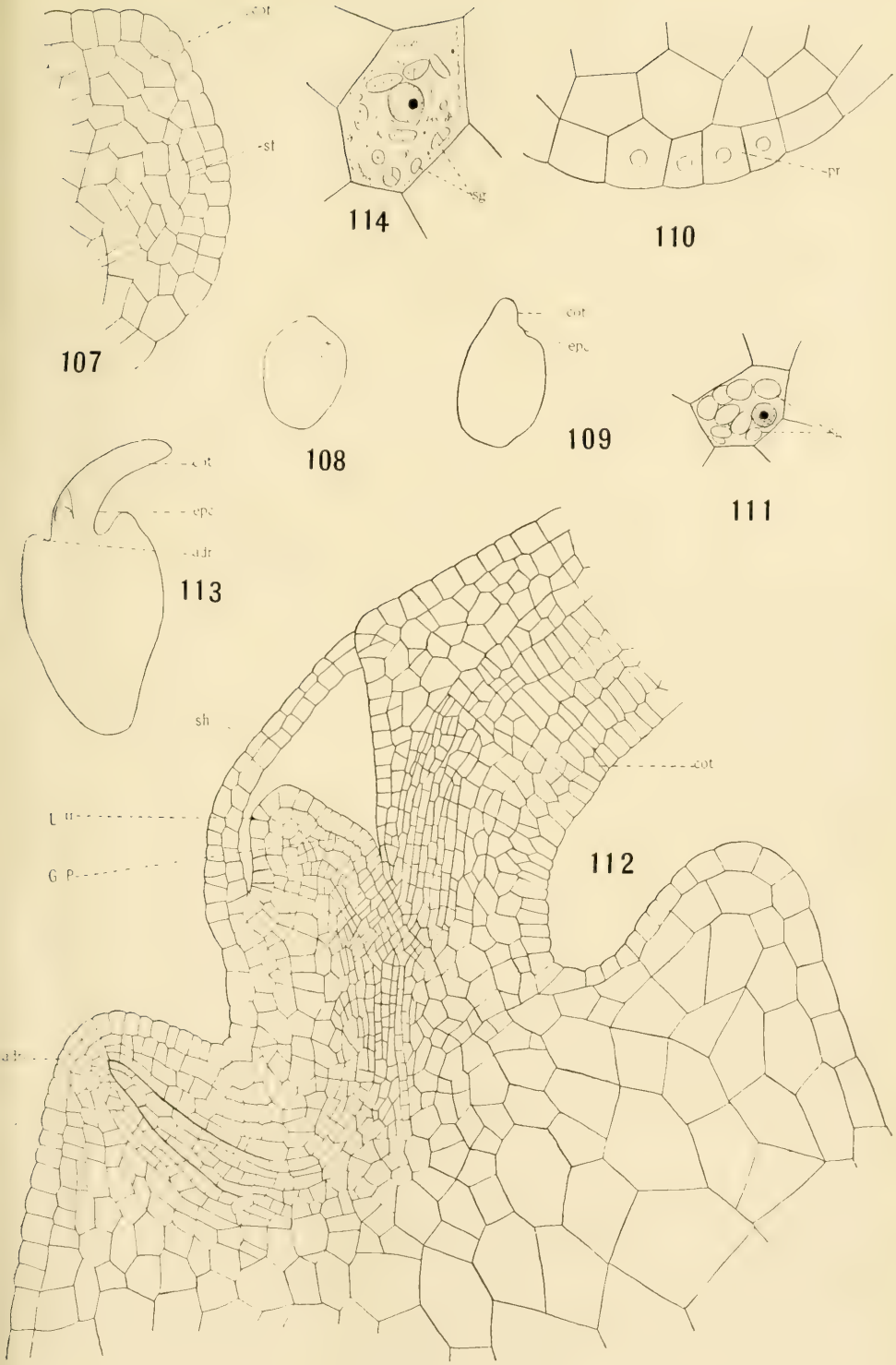
Figure 110.—Basal region of embryo shown in previous figure, illustrating the group of cells which forms the rudimentary primary root. × 300.

Figure 111.—Single storage cell from hypocotyl of embryo shown in figure 109, showing enclosed starch grains. × 600.

Figure 112.—Upper part of longitudinal section of nearly mature embryo shown in figure 113; showing stem-apex with growing-point and second leaf rudiment, part of cotyledon with section of basal sheath, and adventitious root. × 212.

Figure 113.—Longitudinal section of nearly mature embryo from which figure 112 is drawn; showing hypocotyl, epicotyl, cotyledon, and adventitious root. × 35.

Figure 114.—One of storage-cells from hypocotyl of embryo shown in figure 113. × 600.



107

114

110

108

109

111

113

112

PLATE XV

Figure 115.—One of the storage cells from hypocotyl of embryo represented in figure 116, showing increased size of all parts. × 800.

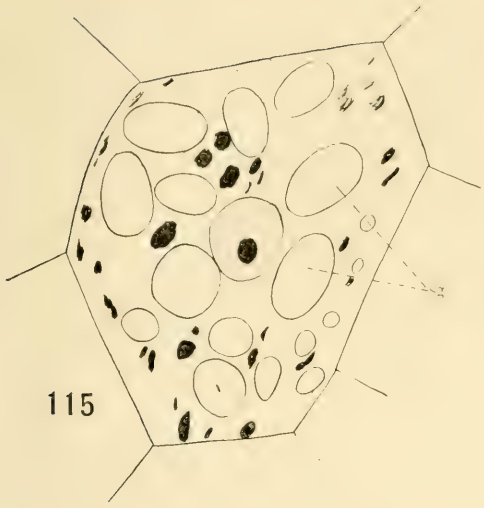
Figure 116.—Nearly mature embryo, older than that shown in figure 113, and showing the parts represented in the latter. × 35.

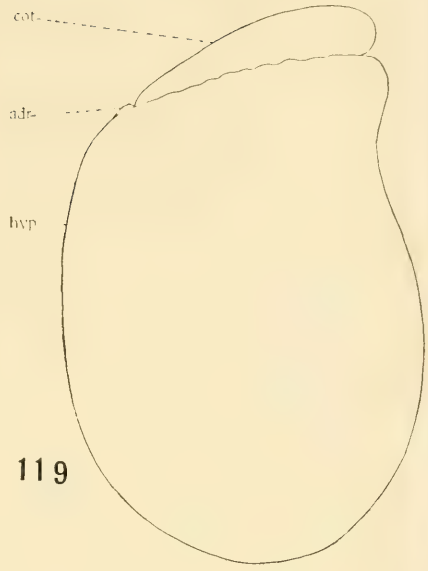
Figures 117 and **118.**—Two views of a cotyledon, dissected from a mature embryo, showing position of epicotyl and the overlying cotyledonary sheaths. Figure 118, represents the narrow cleft between the sheaths. × 35.

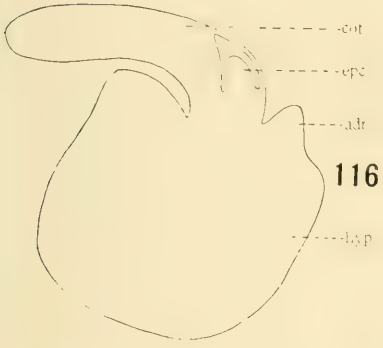
Figure 119.—Mature embryo dissected from ripe seed. × 35.

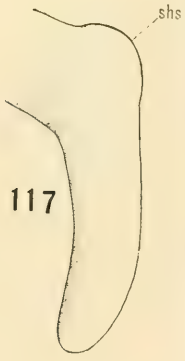
Figure 120.—Seedling about three days old; showing cotyledon and young stem with the first node, adventitious root with root hairs, and the thick, storage part of the hypocotyl still within the hard shell. × 6.

Figure 121.—Two views of young seedling; showing long adventitious root with root hairs, cotyledon, epicotyl, &c. The hard shell has been purposely removed from the hypocotyl. × 6.

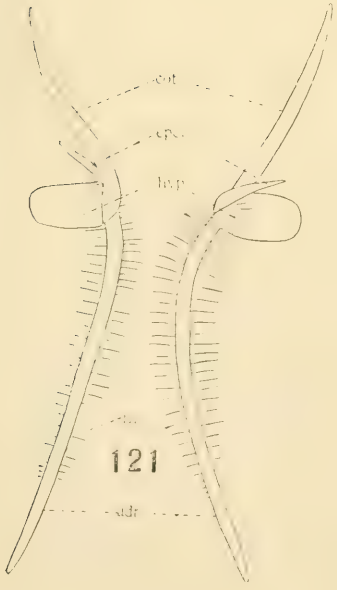

115


cot
adr
hyp
119


cot
epc
adr
116
hyp


shs
117

cut
st
hyp
ah
adr
120


cot
epc
hyp
121
adr

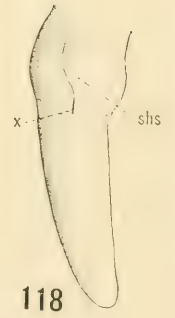

x
shs
118

PLATE I

Figure 1.—*Pedanostethus riparius.* 1a male palpus, outer side. 1b male palpus, inner side. 1c epigynum, usual form. 1d epigynum, unusual variety.

Figure 2.—*Pedanostethus pumilus.* Male palpus, outer side. 2a epigynum.

Figure 3.—*Pedanostethus spiniferus.* Male palpus, inner side. 3a male palpus, outer side. 3b epigynum.

Figure 4.—*Orchestina saltitans.* 4a claws. 4b male palpus.

Figure 5.—*Theridium zelotypum.* Male palpus.

Figure 6.—*Theridium kentuckyense.* Dorsal markings. 6a male palpus.

Figure 7.—*Theridium differens.* Epigynum. Correction of Pl. 1, figs. 1c and 1d, Trans. Conn. Acad., Vol. VI, 1892.

Figure 8.—*Enoplognatha rugosa.* Under side of female. 8a dorsal markings of male. 8b head of female. 8c under side of head and thorax of male.

Figure 9.—*Enoplognatha* (*Steatoda*) *marmorata.* Under side of head and thorax to compare with *rugosa.* 9a mandible from above.

Figure 10.—*Argyrodes cancellatus.* Side of male. 10a side of female. 10b abdomen of male. 10c abdomen of female. 10d epigynum. 10e male palpus.

Plate I

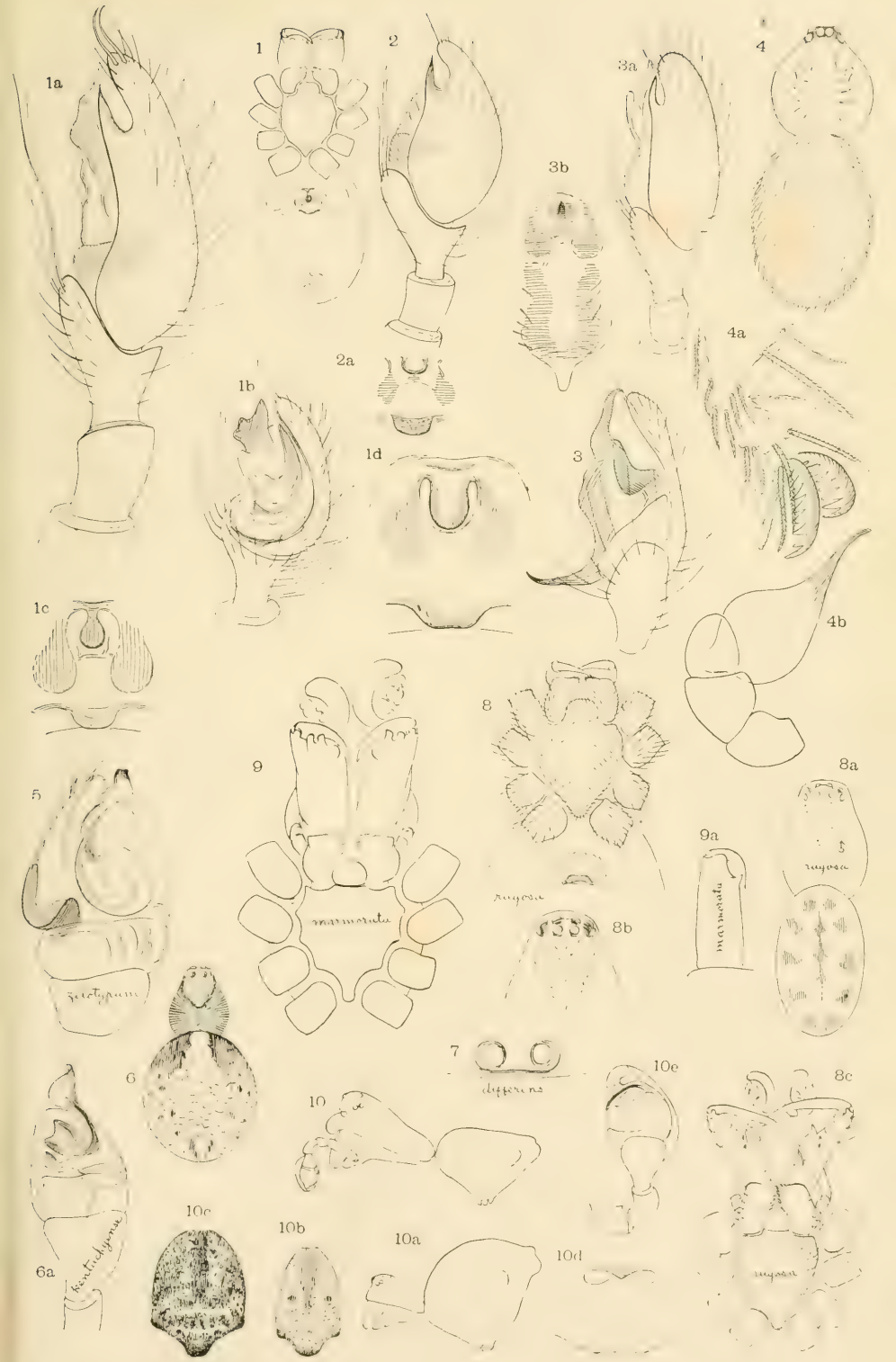

1a
1
2
3a
4
3b
2a
4a
1b
1d
3
1c
4b
8
9
8a
5
9a
marmorata
rugosa
rugosa
8b
zelotypum
7
differens
6
10e
8c
10
10c
10b
10a
10d
6a
kentuckyense
rugosa

PLATE II

Figure 1.—*Caseola herbicola.* 1a, 1b male palpus. 1c epigynum. 1d sternum and maxillæ.

Figure 2.—*Caseola alticeps.* Head and palpus of male. 2a head of male. 2b side of cephalothorax. 2c, 2d male palpus. 2e sternum and maxillæ.

Figure 3.—*Lophocarenum rugosum.* Under side of male. 3a cephalothorax of male. 3b, 3c, 3d, 3e, 3f male palpus. 3g epigynum.

Figure 4.—*Histagonia palustris.* Back of male. 4a side of cephalothorax of male. 4b, 4c, 4d, 4e male palpus. 4f sternum and maxillæ.

Figure 5.—*Ceratinella formosa.* 5a, 5b, 5c male palpus. 5d sternum.

Figure 6.—*Ceratinopsis alternatus.* Male palpus from the side. 6a male palpus from above.

Figure 7.—*Cornicularia clavicornis.* Tibia of male palpus, showing form of two processes extending over the tarsus.

Figure 8.—*Grammonota gigas.* Side of male showing form of head and enlarged metatarsus of first leg. 8a back of male. 8b male palpus.

Figure 9.—*Ceratinopsis auriculatus.* Back of cephalothorax and palpi of male. 9a side of cephalothorax and palpus. 9b male palpus.

Figure 10.—*Erigone brevidentatus.* Mandibles and palpi of male. 10a cephalothorax of male. 10b sternum and maxillæ. 10c male palpus from above.

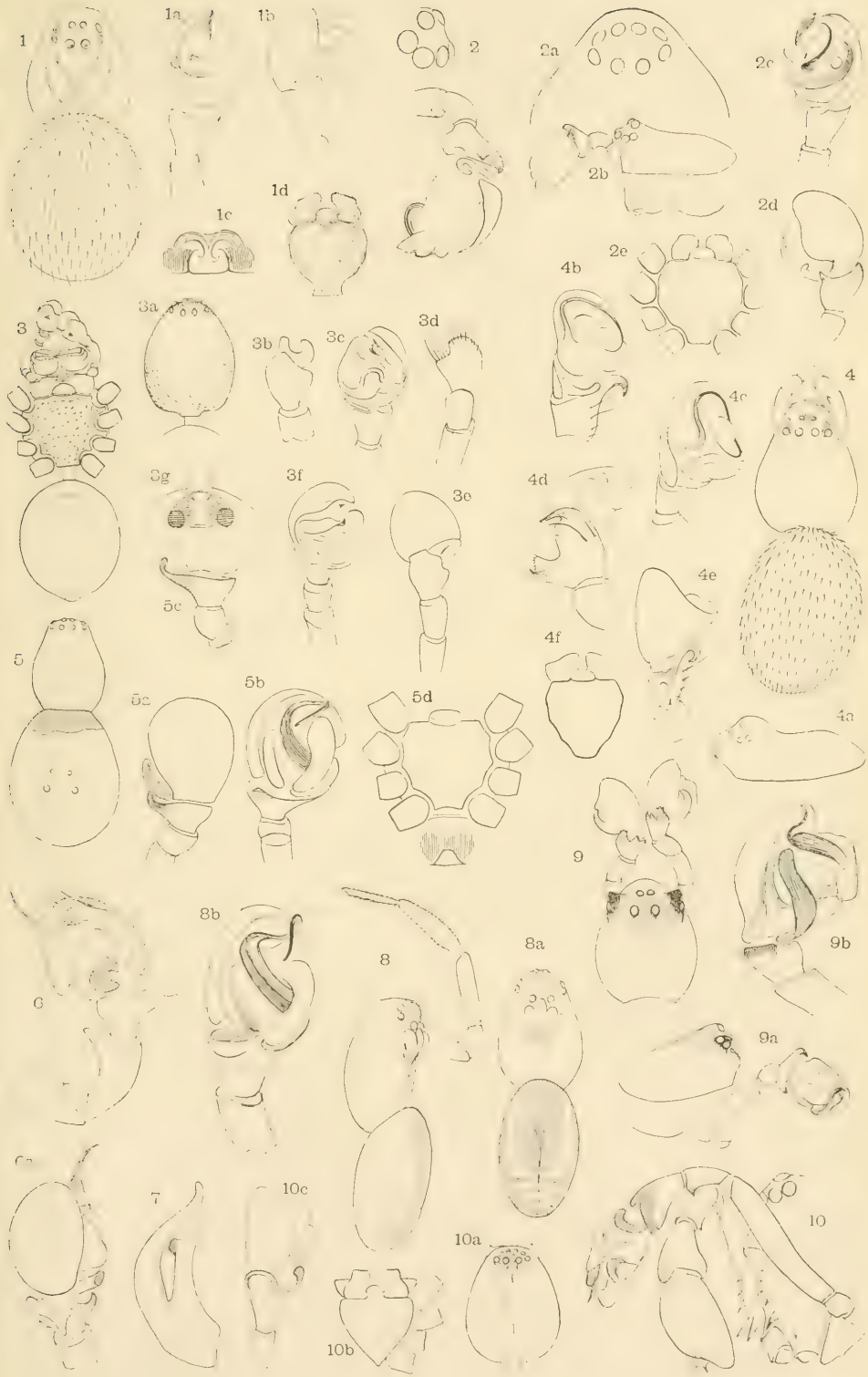

1
1a
1b
1c
1d
2
2a
2b
2c
2d
2e
3
3a
3b
3c
3d
3e
3f
3g
4
4a
4b
4c
4d
4e
4f
5
5b
5c
5d
5e
6
7
8
8a
8b
9
9a
9b
10
10a
10b
10c

PLATE III

Figure 1.—*Lophocarenum trilobatum.* Cephalothorax and palpi of male. 1a same, from the side.

Figure 2.—*Lophocarenum longitubum.* Epigynum. 2a head of female.

Figure 3.—*Lophocarenum alpinum.* 3a head of male. 3b head and mandibles of male from the front. 3c immature male. 3d female. 3e epigynum. 3f patella and tibia of male palpus.

Figure 4.—*Lophocarenum quadricristatum.* Head of female. 4a epigynum and end of sternum.

Figure 5.—*Lophocarenum abruptum.* 5a head of male. 5b male palpus from above. 5c male palpus from below.

Figure 6.—*Lophocarenum cuneatum.* Head and palpi of male. 6a same from the side. 6b epigynum. 6c head of female.

Figure 7.—*Lophocarenum pallidum.* Head of male. 7a same from the side. 7b patella and tibia of male palpus. 7c male palpus showing tarsal hook and tibia from above.

Figure 8.—*Lophocarenum minutum.* Cephalothorax and palpi of male. 8a epigynum and end of sternum of female. 8b male palpus.

Plate III

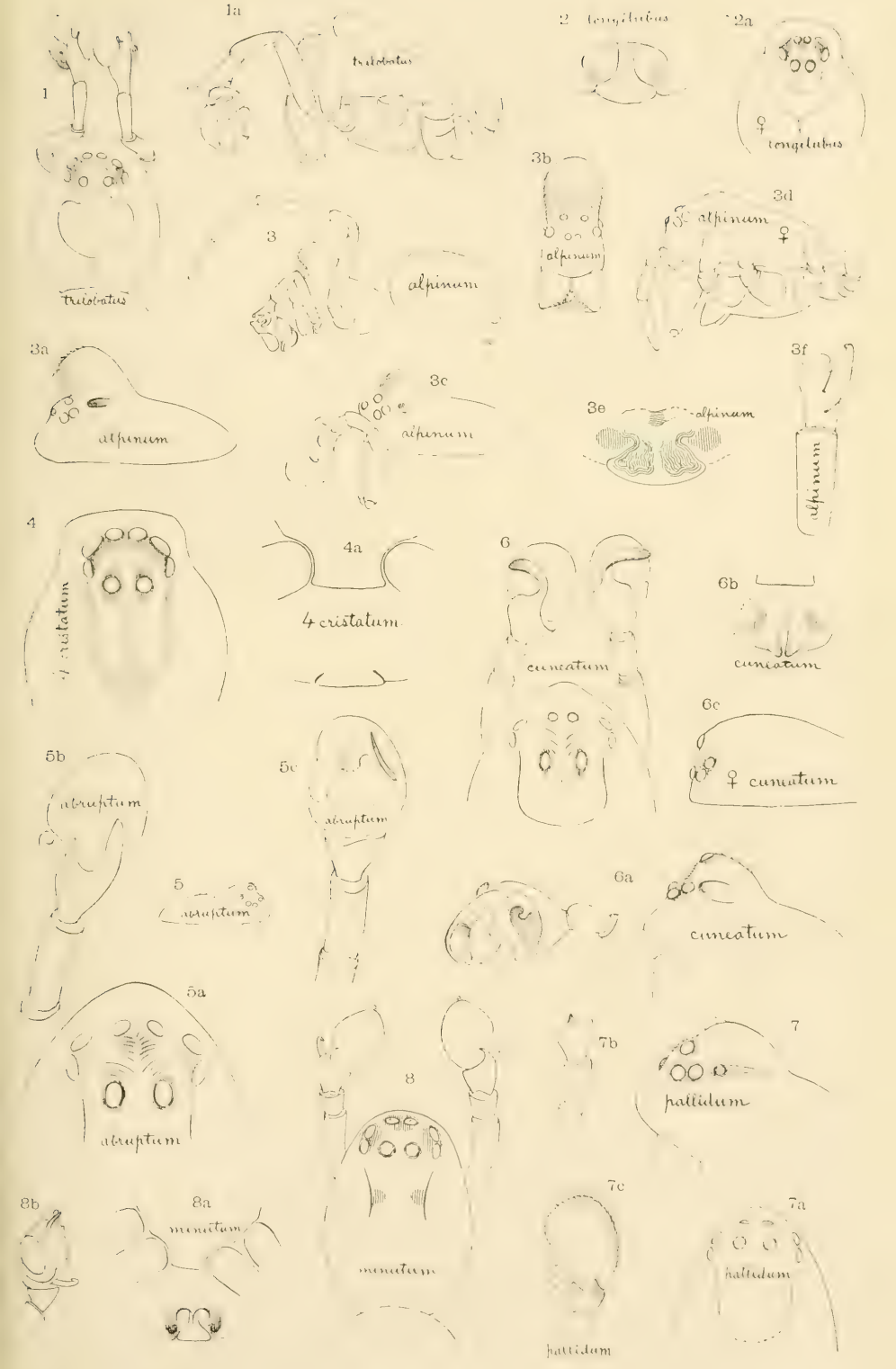

1
trilobatus
1a
trilobatus
2 longilubus
2a
♀ longilubus
3
alpinum
3a
alpinum
3b
alpinum
3c
alpinum
3d
alpinum ♀
3e
alpinum
3f
alpinum
4
4 cristatum
4a
4 cristatum
5
abruptum
5a
abruptum
5b
abruptum
5c
abruptum
6
cuneatum
6a
cuneatum
6b
cuneatum
6c
♀ cuneatum
7
pallidum
7a
pallidum
7b
7c
pallidum
8
minutum
8a
minutum
8b

PLATE IV

Figure 1.—*Tmeticus probatus.* Male palpus. 1a same from above showing processes of tibia. 1b epigynum.

Figure 2.—*Tmeticus truncatus.* Male palpus. 2a same showing form of tibia.

Figure 3.—*Tmeticus debilis.* Palpal organ. 3a, 3b male palpus from above showing tarsus and hook.

Figure 4.—*Tmeticus corticarius.* Male palpus from above. 4a male palpus from side. 4b epigynum.

Figure 5.—*Tmeticus terrestris.* Epigynum.

Figure 6.—*Tmeticus bidentatus.* Epigynum.

Figure 7.—*Tmeticus brunneus.* Epigynum. 7a epigynum from side. 7b male palpus.

Figure 8.—*Tmeticus flaveolus.* Epigynum and end of sternum. 8a, 8b male palpus showing spines at base of tarsus.

Figure 9.—*Tmeticus longisetosus.* Epigynum.

Figure 10.—*Linyphia maculata.* Front of head and mandibles of female. 10a female from above. 10b same from side. 10c male. 10d, 10e, 10f male palpus. 10g epigynum.

Figure 11.—*Microneta persoluta.* Male palpus. 11a epigynum.

Figure 12.—*Microneta latidens.* Abdomen of female with markings. 12a male palpus from above. 12b male palpus from side. 12c epigynum. 12d epigynum from side.

Figure 13.—*Bathyphantes calcaratus.* Dorsal markings. 13a male palpus from side.

Figure 14.—*Microneta denticulata.* Male palpus.

Figure 15.—*Microneta serrata.* Male palpus from the side. 15a same from below. 15b same from above.

Plate IV

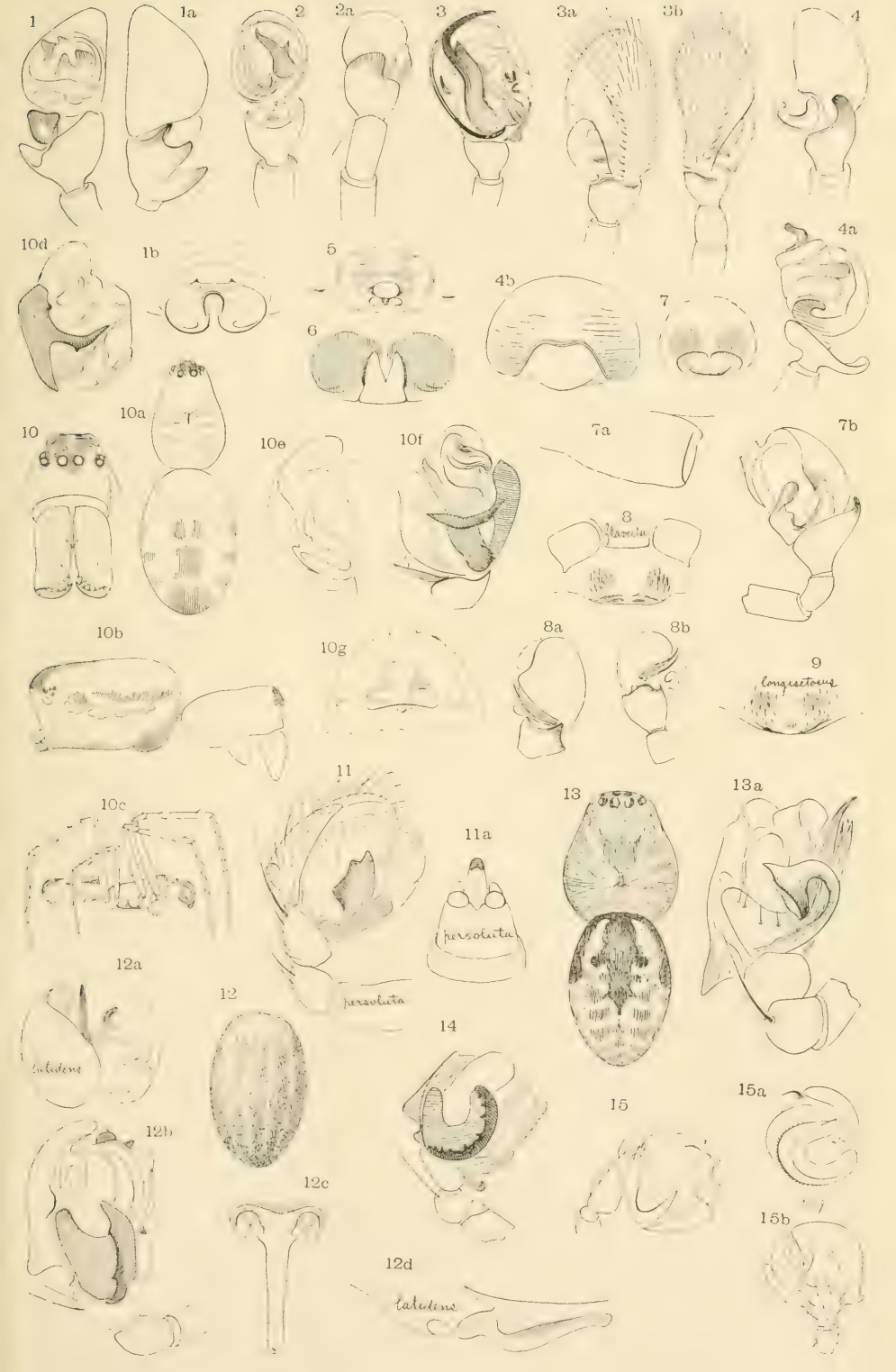

1
1a
2
2a
3
3a
3b
4
4a
4b
5
6
7
7a
7b
8
8a
8b
9
longisetosus
10
10a
10b
10c
10d
10e
10f
10g
11
11a
12
12a
12b
12c
12d
13
13a
14
15
15a
15b
persoluta
persoluta
latidens
latidens

PLATE V

Figure 1.—*Epeira juniperi*, male. 1a first and second legs.

Figure 2.—*Epeira thaddeus*, male. 2a first and second legs.

Figure 3.—*Epeira corticaria*, male. 3a patella and tibia of second leg.

Figure 4.—*Zilla atrica*, female. 4a palpus of male. 4b epigynum of *Zilla montana*. 4c epigynum of *Zilla atrica*. 4d epigynum of Z. x-notata.

Figure 5.—Pairing of *Tetragnatha vermiformis*. 5a Hold of mandibles of male and female.

Figure 6.—*Pachygnatha tristriata*. 6a male palpus. 6b head of *P. brevis*. 6c head of P. tristriata. 6d head of *P. autumnalis*.

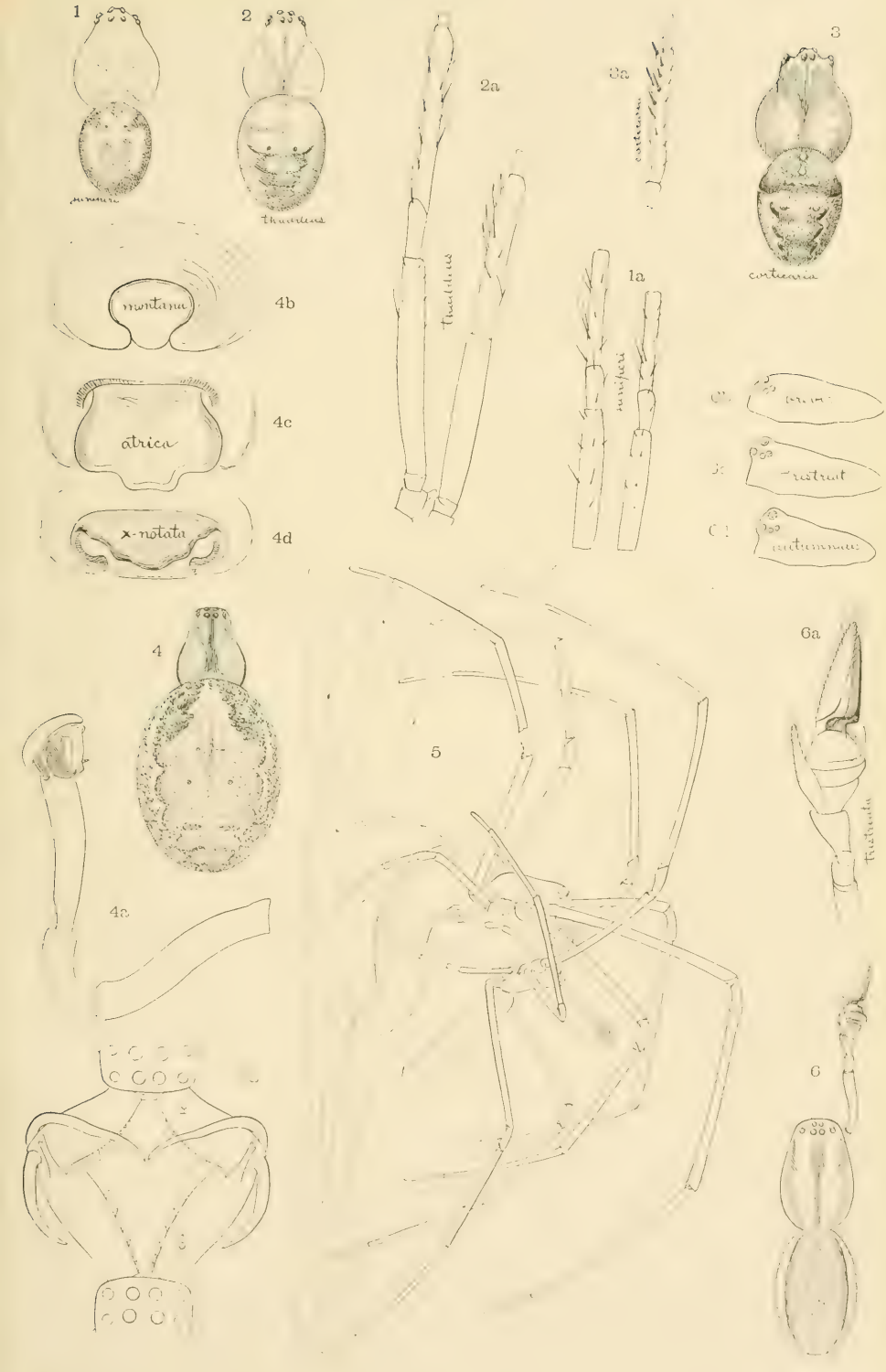

1
2
2a
3a
3
1a
4b
montana
4c
atrica
4d
x-notata
4
4a
5
6a
6

PLATE VI

Figure 1.—*Lycosa relucens.* 1a male palpus. 1b epigynum.

Figure 2.—*Lycosa ocreata.* Epigynum. 2a male palpus.

Figure 3.—*Lycosa crassipalpis.* 3a male palpus.

Figure 4.—*Lycosa (Pardosa) bilineata.* Epigynum. 4a first leg of male. 4b male palpus.

Figure 5.—*Pardosa littoralis.* 5a male palpus. 5b epigynum.

Figure 6.—*Pardosa diffusa,* male. 6a palpal organ. 6b epigynum.

Figure 7.—*Pirata insularis.*

Figure 8.—*Pirata sylvestris.* 8a male palpus. 8b, 8c epigynum.

Figure 9.— *Pirata arenicola,* male. 9a head of female. 9b male palpus. 9c epigynum.

Figure 10.—*Pirata maculata,* female. 10a under side. 10b epigynum.

Figure 11.—*Trabea (Aulonia) aurantiaca.*

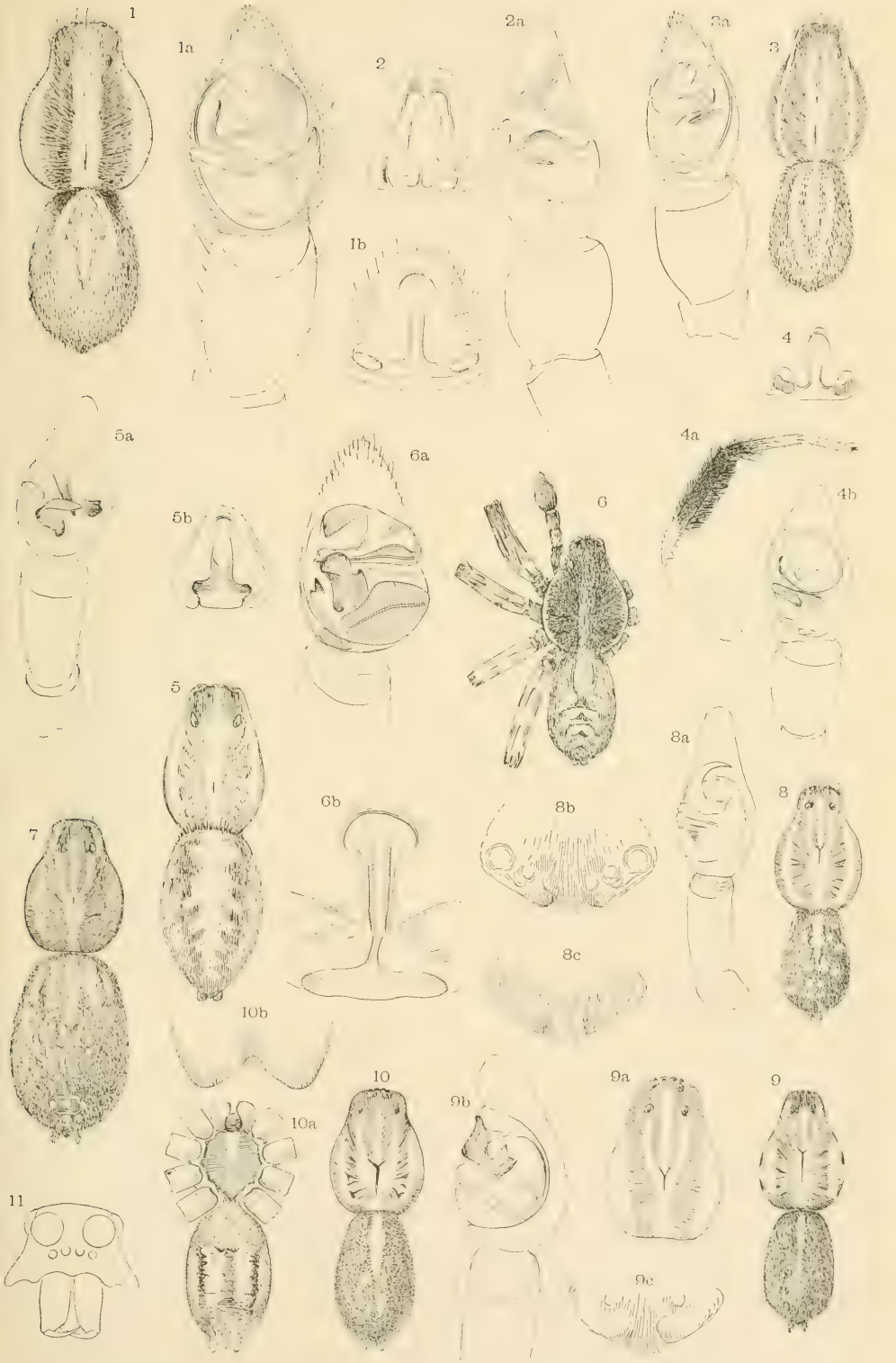

1
1a
2
1b
2a
3a
3
4
5a
5b
6a
6
4a
4b
5
6b
8a
8b
8
7
8c
10b
10
10a
9b
9a
9
11
9c

PLATE VII

Figure 1.—*Lycosa baltimoreana.* 1a markings of under side of abdomen. 1b epigynum.

Figure 2.—*Lycosa avara.* Epigynum. 2a head of female.

Figure 3.—*Lycosa nidifex.* First leg of male. 3a first leg of female. 3b epigynum. 3c male palpus. 3d first leg of male, *L. pikei,* 3e first leg of female, *L. pikei.*

Figure 4.—*Lycosa punctulata.* Male palpus. 4a epigynum.

Figure 5.—*Lycosa scutulata.* Male palpus.

Figure 6.—*Dolomedes sexpunctatus,* female. 6a male palpus. 6b young female.

Figure 7.—*Dolomedes vernalis,* male. 7a front of head. 6b epigynum. 7c, 7d male palpus.

Figure 8.—*Dolomedes idoneus.* Epigynum.

Plate VII

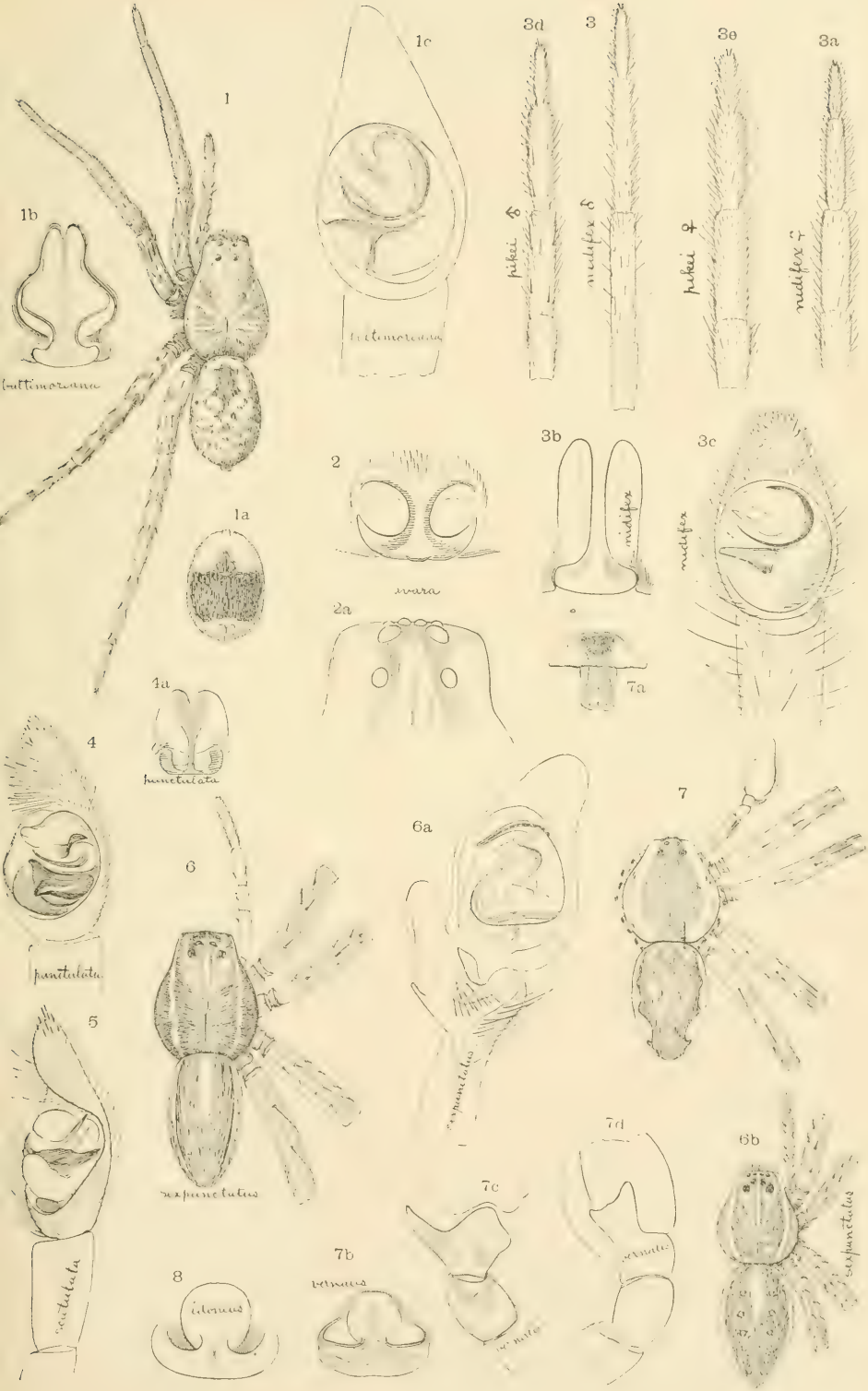

1
1a
1b
1c
2
2a
3
3a
3b
3c
3d
3e
4
4a
5
6
6a
6b
7
7a
7b
7c
7d
8
pikei ♂
nidifex ♂
pikei ♀
nidifex ♀
nidifex
avara
punctulata
sexpunctatus
idonus
vernalis

PLATE VIII

Figure 1.—*Œcobius parietalis*, female. 1a under side of abdomen. 1b epigynum. 1c spinnerets and anal tubercle. 1d. calamistrum. 1e male palpus.

Figure 2.—*Scotolathys pallidus*. Male palpus, upper side. 2a male palpus under side. 2b eyes. 2c calamistrum. 2d epigynum.

Figure 3.—*Amaurobius borealis*. Epigynum. 3a, 3b, 3c male palpus. 3d spinnerets.

Figure 4.—*Cryphœca montana*, female. 4a spinnerets. 4b epigynum. 4c eyes. 4d sternum. 4e, 4f male palpus. 4g first leg, inner side. 4h first leg, outer side. 4i eyes from in front.

Figure 5.—*Hahnia brunnea*.

Figure 6.—*Cicurina brevis*. Cephalothorax of male. 6a, 6b male palpus. 6c epigynum.

Figure 7.—*Cicurina pallida*. Cephalothorax of male. 7a, 7b male palpus. 7c epigynum.

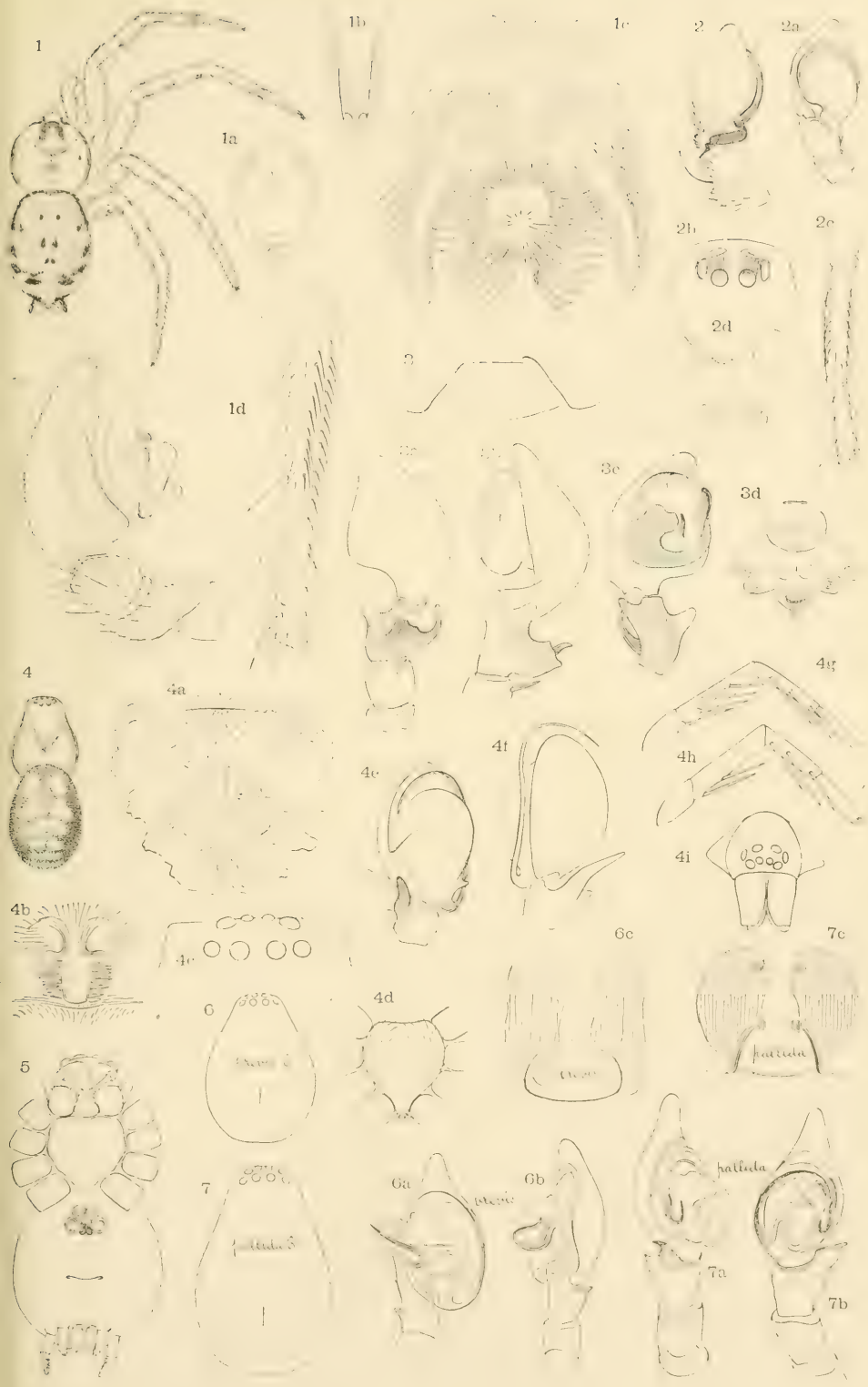

1
1a
1b
1c
2
2a
2b
2c
2d
1d
3
3c
3d
4
4a
4b
4c
4d
4e
4f
4g
4h
4i
6c
7c
5
6
7
6a
6b
7a
7b
pallida

PLATE IX

Figure 1.—*Drassus hiemalis.* 1a, 1b male palpus. 1c eyes. 1d epigynum.

Figure 2.—*Drassus bicornis.* 2a male palpus. 2b epigynum.

Figure 3.—*Gnaphosa parvula.* Epigynum, 3a, 3b male palpus.

Figure 4.—*Pœcilochroa montana.* Sternum and maxillæ of male. 4a tibia of male palpus, inner side. 4b male palpus, outer side.

Figure 5.—*Poecilochroa variegata.* Sternum and maxillæ of male, to compare with *montana.*

Figure 6.—*Prosthesima rufula.* 6, 6a, 6b, 6c variations of epigynum. 6d spinnerets. 6e, 6f male palpus. 6g sternum and maxillæ. 6h eyes.

Figure 7.—*Apostenus acutus.* 7a eyes. 7b, 7c male palpus.

Figure 8.—*Anyphœna rubra,* male palpus from below. 8a mandible of male. 8b, 8c male palpus.

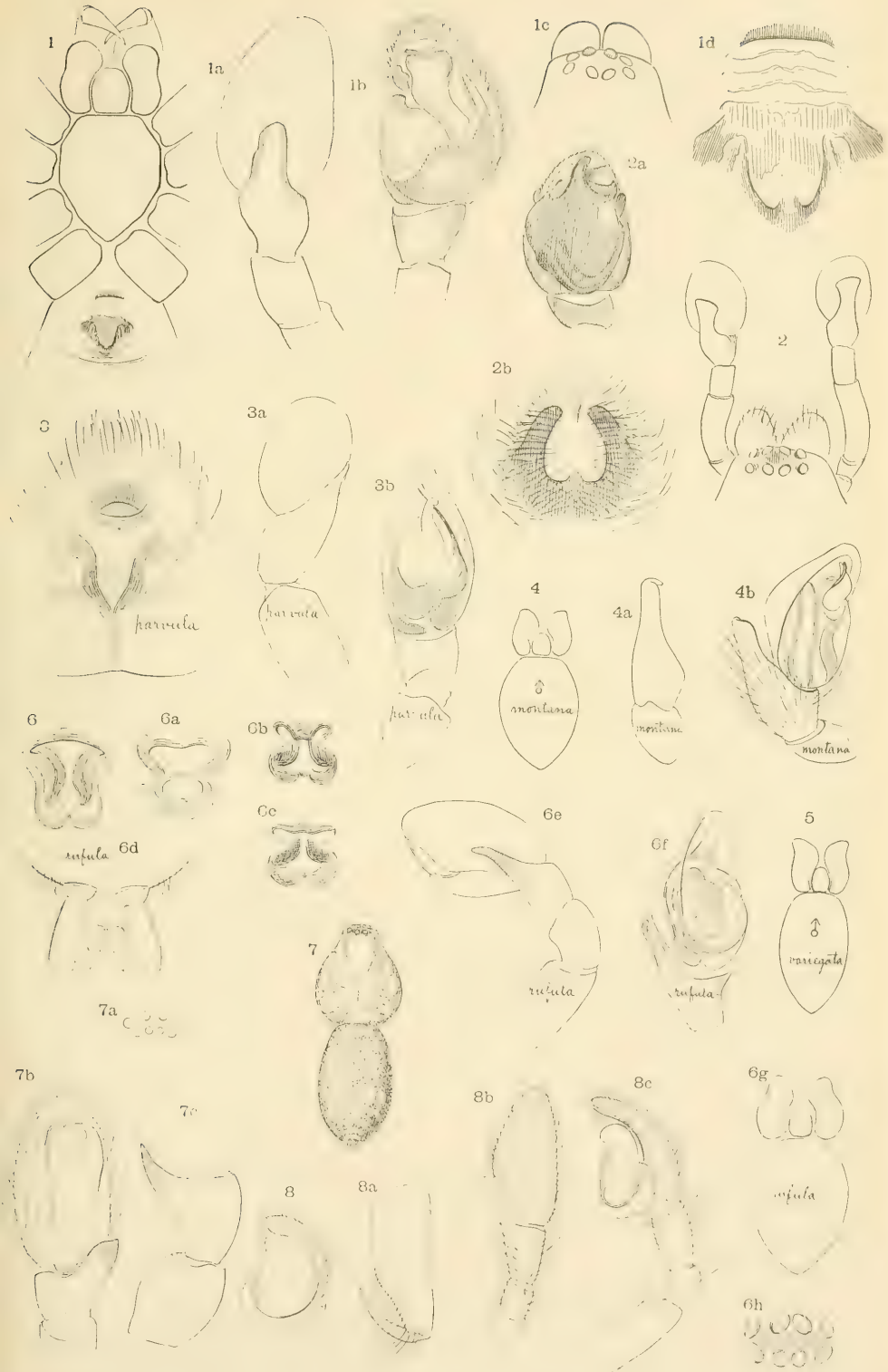

1
1a
1b
1c
1d
2a
2
2b
3
parvula
3a
parvula
3b
parvula
4
montana
4a
montana
4b
montana
6
6a
6b
6c
rufula 6d
7a
6e
rufula
6f
rufula
5
variegata
7
7b
7c
8
8a
8b
8c
6g
rufula
6h

PLATE X

Figure 1.—*Micaria quinquenotata,* male and female pairing. 1a male palpus. 1b cephalothorax of male. 1c same from side. 1d eyes. 1S epigynum.

Figure 2.—*Micaria longipes.* 2, 2a cephalothorax of male, to compare with *quinquenotata.*

Figure 3.—*Micaria gentilis,* female. 3a male. 3b, 3c male palpus. 3d epigynum.

Figure 4.—*Micaria laticeps.* 4a, 4c male palpus. 4b sternum and maxillæ.

Figure 5.—*Castaneira lineata,* sternum and maxillæ of female. 5a epigynum. 5b cephalothorax.

Figure 6.—*Clubiona riparia (ornata).* 6, 6a, 6b male palpus. 6c epigynum.

Figure 7.—*Clubiona præmatura.* Male palpus, under side. 7a tibia from above, 7b epigynum.

Figure 8.—*Clubiona canadensis.* Male pulpus. 8a epigynum.

Figure 9.—*Clubiona rubra.* Epigynum.

Figure 10.—*Clubiona spiralis.* Male palpus showing tibial hook. 10a same from side. 10b palpal organ from below. 10c epigynum.

Figure 11.—*Clubiona crassipalpis.* Epigynum.

Figure 12.—*Clubiona tibialis.* Epigynum.

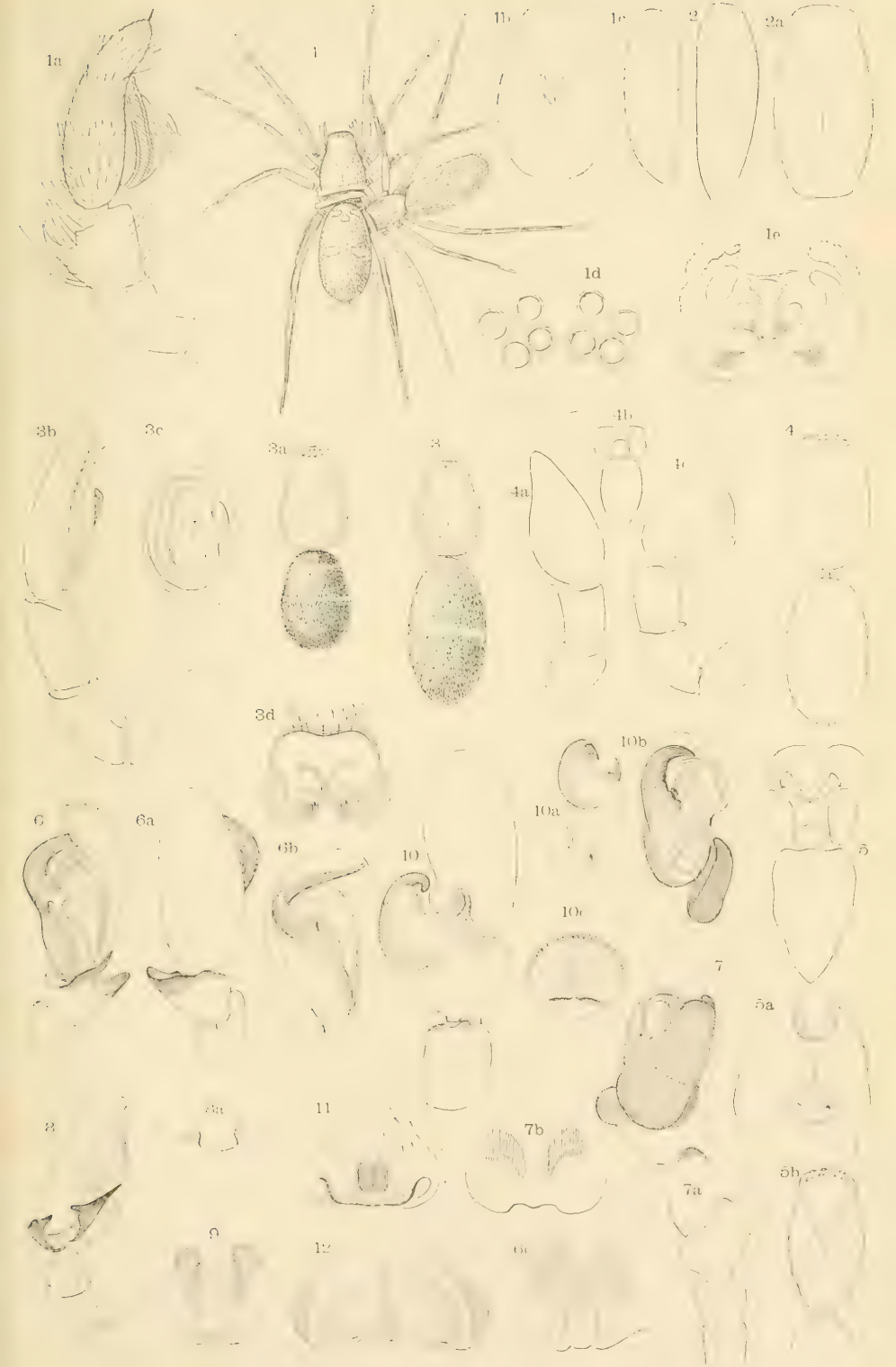

1a
1
1b
1c
2
2a
1e
1d
3b
3c
3a
3
4b
4
4a
1
3d
10b
10a
6
6a
6b
10
10c
5
7
5a
8
8a
11
7b
5b
7a
9
12
6c

PLATE XI

Figure 1.—*Phidippus brunneus.* Male palpus.

Figure 2.—*Phidippus insignarius,* female. 2a male. 2b male from in front. 2c epigynum. 2d under side of abdomen.

Figure 3.—*Dendryphantes Jeffersoni.* 3a male palpus. 3b end of palpal organ. 3c tibia of male palpus. 3d epigynum. 3e epigynum of *D. militaris.*

Figure 4.—*Dendryphantes flavipedes.* Tibia of male palpus. 4a palpal organ.

Figure 5.—*Phidippus Whitmani.* Male palpus.

Figure 6.—*Mœvia (Admestina) Wheeleri.*

Figure 7.—*Hyctia Pikei.* Under side of female. 7a back of female. 7b male approaching female. 7c male palpus.

Figure 8.—*Icius formicarius,* male from the side. 8a male palpus.

Figure 9.—*Homalattus cyaneus.* 9a side of same.

Plate XI

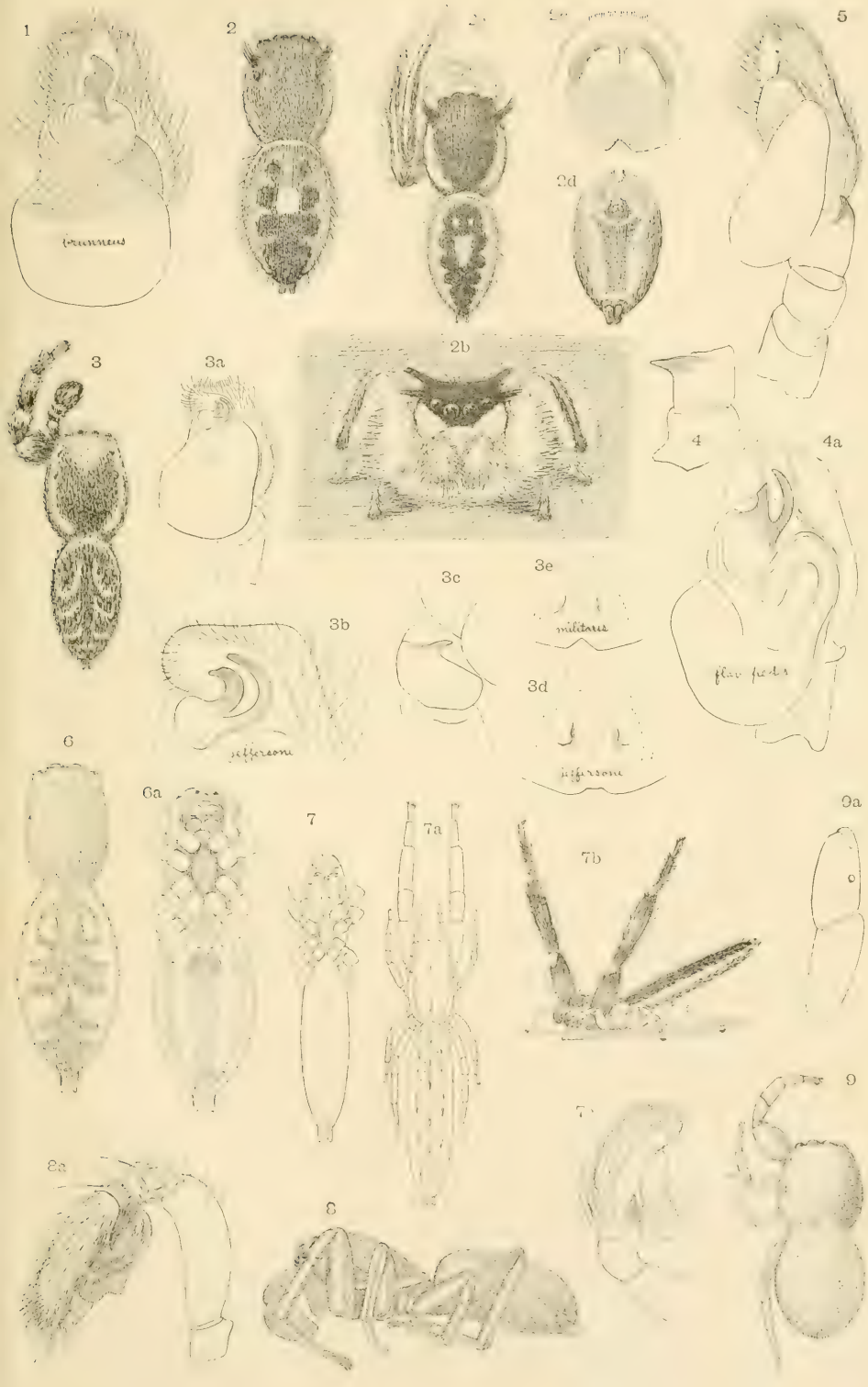


PLATE XII

Figure 1.—*Phidippus Whitmani,* male.

Figure 2.—*Pellenes roseus,* male.

Figure 3.—*Pellenes agilis,* female. 3a male in the position taken when approaching the female. 3b male approaching female, front view.

Figure 4.—*Pellenes borealis,* male. 4a female. 4b male palpus. 4c epigynum.

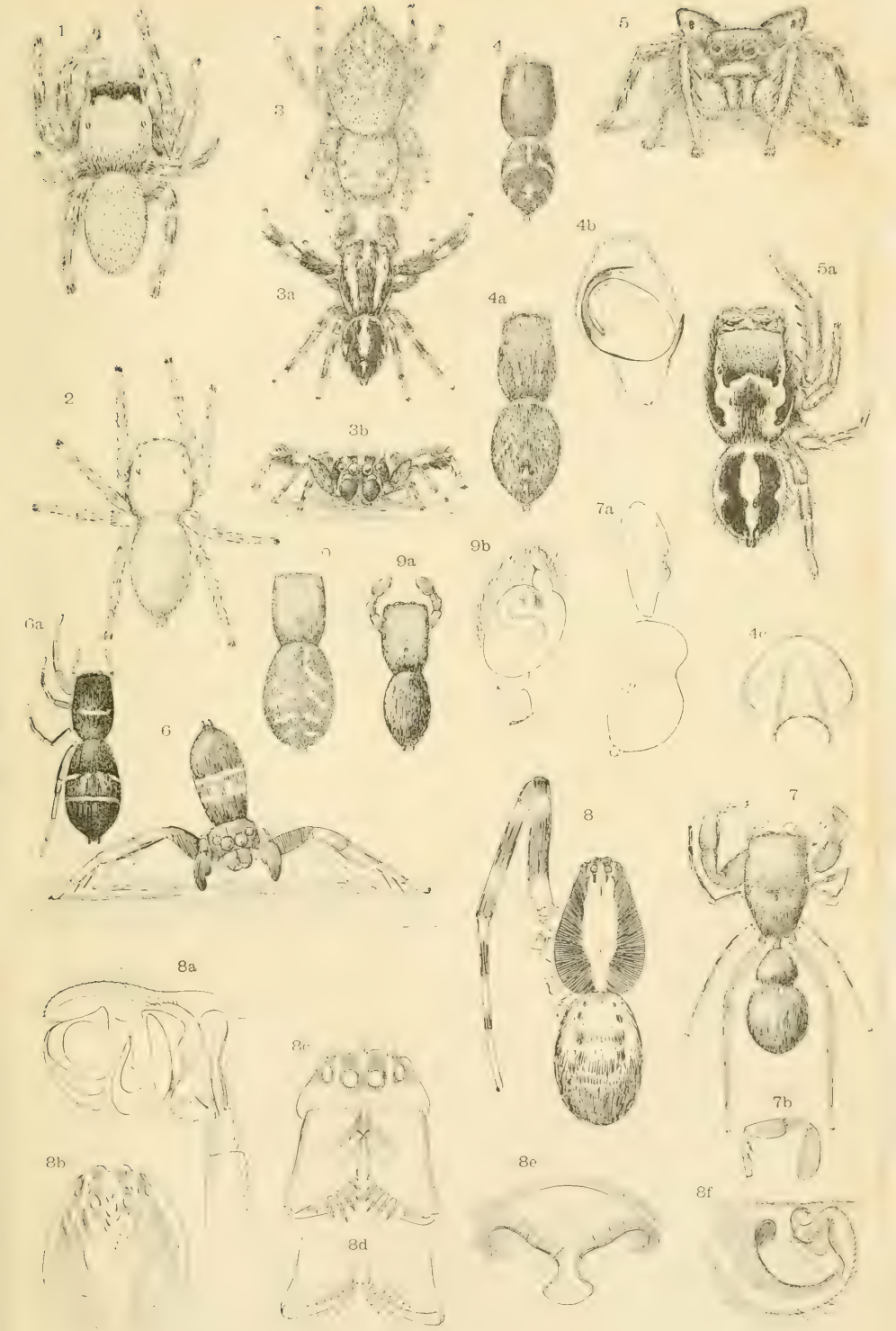
Figure 5.—*Pellenes viridipes,* male from in front. 5a back of male.

Figure 6.—*Peckhamia scorpionia,* male approaching the female. 6a female.

Figure 7.—*Peckhamia picata,* male. 7a side of male. 7b first leg of male, inner side.

Figure 8.—*Tapinopa bilineata,* female. 8a male palpus. 8b head of male. 8c front of head of female. 8d mandibles, inner side, 8e, 8f epigynum.

Figure 9.—*Chalcoscirtus montanus,* female. 9a male. 9b male palpus.


1
3
4
5
4b
3a
4a
5a
2
3b
7a
9b
9a
6a
4c
6
8
7
8a
8c
7b
8b
8e
8f
8d

MBL WHOI Library - Serials
5 WHSE 02798